CROSS TALK

▸SCR-268 . . . With this cryptic title, the Signal Corps labels its first radar set designed in the Signal Corps Laboratories at Fort Monmouth under the general direction of General (then Colonel) Colton, built by Western Electric, operated by the Army here, there, and everywhere in the dark early days of the war. Now completely declassified, the 268 is adequately described for the first time in this issue of ELECTRONICS. The manuscript has been in our safe for months, properly passed by the Office of Censorship. Since no definite policy on publication of radar information had been formulated, however, the War Department felt that the article should not be published in spite of the fact that the set had been compromised by both Germany and Japan months ago and in spite of the fact that more modern versions of radar surpass the 268 in every respect.

As most of ELECTRONICS' readers know, a previous period existed in which radar as a subject could be mentioned in print. Then censorship clamped down again, hard, because too much was mentioned and implied in print and because of the incipient triangular duel over who developed radar—the Americans or the British, the Army or the Navy, this laboratory or that one. Vieing with each other in making claims in advertising, manufacturers threatened, collectively, to give away too much information; and so nothing whatever could be said for quite some time.

Then, in Chicago, labor troubles developed. More workers were needed to make parts and assemblies used in radar. Manufacturers wanted to state in print that jobs on radar were waiting. New permission was granted to use the term publicly provided there was no mention of how radar worked or what it did.

All of this mystery whetted the appetite of the public, the publishers, and of anybody else whose curiosity was easily intrigued. Here was something new, something wonderful, and—above all—something hot. In the meantime, the SCR-268 had served its purpose; had been captured with blueprints and operators, had been made obsolete by new research.

There is one other bit of history that should be known. In the summer of 1940, English scientists came to this country looking for help. They put their cards on the table, telling American scientists everything that England had up its sleeve in exchange for information on our new defensive and offensive devices. They asked one thing—that nothing be published about these matters until the British were ready because English law makes it impossible to protect oneself by patent on any device that has been described in print.

The first break in the dam preventing more adequate publication of radar principles came when R. L. Smith-Rose published two papers on the subject in the *Wireless World* of London. Since then, considerable effort has been made to relax censorship on the whole subject so that the principles can become known and can be put to much wider use than in purely military devices.

An agreement has now been reached on radar. Other policies have been established which will permit more rapid and complete publication of data on all our wartime research. Thus much of the fine work carried out by hundreds of the nation's best scientists under OSRD will become available to the credit of those who, valiantly and silently and without acclaim, have labored so long behind locked doors. Much of their research will have direct application to industry and communications.

Other articles similar to the present SCR-268 story and much of the hitherto secret wartime electronic developments accomplished under OSRD will see daylight through the editorial pages of ELECTRONICS.

▸U-235 . . . There have been many best-kept secrets of the war, but none approaches the Manhattan Project, the cloud under which the Army obscured its work on the atomic bomb. News of the bomb was released just as this issue of ELECTRONICS went to press. The basic background, however, was published in our July 1940 issue and is reprinted in the Electron Art department this month.

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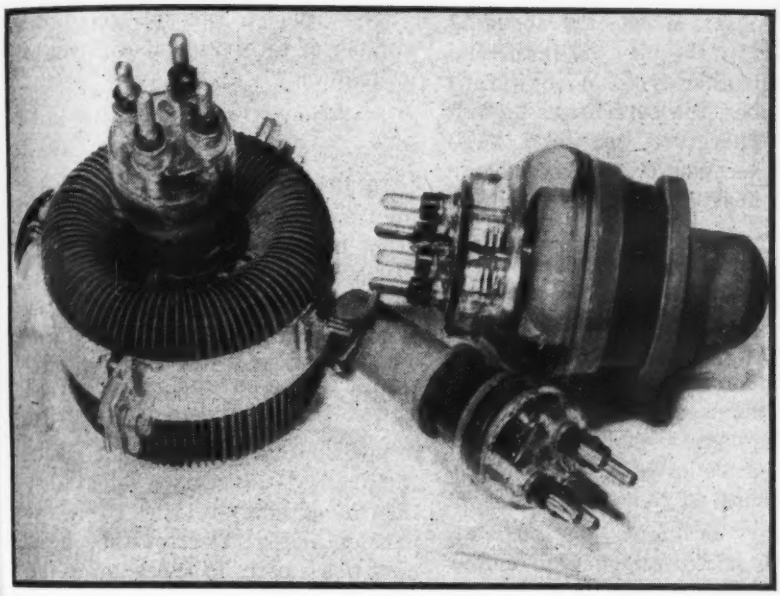
TUBE BUSINESS



turers of munitions and ordnance devices know that their tremendous volume of business is solely a war phenomenon. The same is true of the aircraft manufacturers.

It is the writer's opinion that far too many men now connected with the sale and manufacture of electron tubes harbor the belief that somehow or other the present huge demand for electron tubes will be maintained at nearly its present volume during the postwar period. Many men, particularly engineers, who have been active optimists and enthusiastic promoters of electronics over the leaner years still retain their faith and enthusiasm but now, in comparison with the newcomers, are considered cynical and pessimistic. What the layman sometimes forgets is that electron tubes are not consumed directly but can be sold only for installation in new equipment or as replacements for tubes that have ended their useful life in equipment being operated.

World War II has been characterized by the vast number of engine-driven units, such as tanks, planes and landing craft, that are being used. In total, these are known to number many hundreds of thousands, and each has at least one complete radio transmitter and receiver.

In the case of radio transmitting tubes, there are two factors that have inflated the tube requirements beyond the wartime increase in apparatus using them. The first of these arises from the fact that the useful life of electronic equipment in wartime is bound to be much shorter than the obsolescence life in normal use. Experience has indicated that commercial electrical equipment is capitalized on a basis of 10 to 20 years. The life expectation of radio equipment in wartime is probably more like these figures in months rather than in years.

The second factor is the large number of spare tubes that must be manufactured for each socket put into use. This is largely due to the fact that we are engaged in a global war. Tanks, planes and ships may have to be used and serviced in huge numbers in dozens of localities widely scattered throughout the world. Therefore, spare and replacement tubes have been produced and distributed in a ratio far exceeding that required for normal or peacetime electronic devices.

This enormous war inflation is indicated in the case of the Navy by the following paragraph from a paper by Captain J. B. Dow, Director of the Electronics Division of the Bureau of Ships:[1]

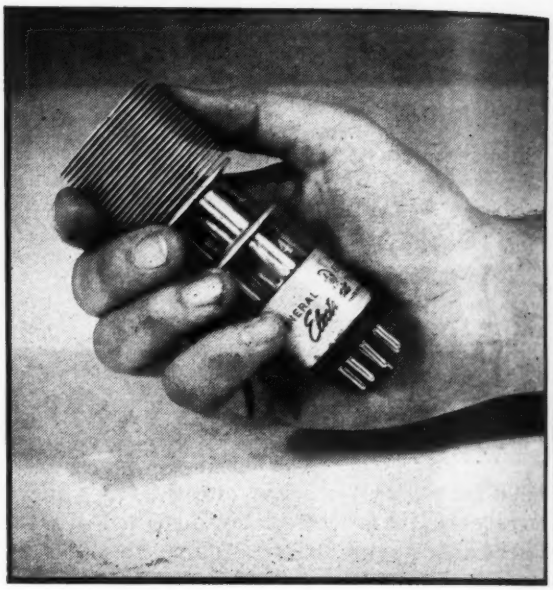
> "At the end of December, 1941, the Navy comprised a total of 2082 vessels and landing craft, in each of which at least one transmitter and two receivers were installed. As of December 1, 1944, this figure had risen as a result of the ship-building program to 37,981. A large carrier has installed in it 101 complete equipments. A small motor torpedo-boat has seven. Certain of the smaller types of landing craft have as many as 13 complete equipments; others have as few as three. It is estimated that since December 7, 1941, some 300,000 complete equipments, each comprising two to 15 major units of equipment, have been installed in these 38,000 vessels and landing craft."

Postwar Estimates

There are a number of approaches to the problem of estimating the postwar demands for electron tubes. One interesting

Postwar ELECTRON T

Potential demand for receiving, transmitting and industrial types is estimated and compared with the best prewar year. The outlook for complete electronic equipment in both old and new categories is simultaneously discussed



By W. C. WHITE
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A FEW MONTHS AGO there appeared in a leading New York City newspaper the following two-column heading: "Electrons Now Make Huge Propellers For Our Warships in 700 Percent Faster Time."

At about the same time, a well-rated popular-science magazine enjoying a wide circulation contained the following item:

> "Electronic rat trap operates when a rat passing through an open tunnel cuts an invisible ray beamed on a photocell. Trap doors drop down at both ends and the rat, seeing light above, goes up a ramp to a small chamber where he steps on a switch plate which turns on a current to electrocute him."

Also, the writer recently received a letter which read as follows:

> "It has been proposed to convert a certain amusement park steam locomotive from a coal burner to an oil burner on account of the smoke and cinder nuisance.
>
> "The miniature railroad is located in the . . . area, the gage of track is 16 inches and the locomotive and tank weigh about one ton in working order.
>
> "My object in writing to you is to inquire if instead of using oil as a fuel to generate steam it would be either possible or practical to install an electronic heating device in the fire box."

These three instances are examples of present-day fallacies regarding electronics, although in the first two cases the publications could hardly be criticized for printing them or featuring them.

The first case, the newspaper heading, was a report on an engineering paper presented at a technical society meeting. It described an elaborate piece of equipment designed to do a difficult job in a new and better way. If one examines the paper in detail, however, it is to be noted that only one electron tube is used per unit. The tube could be one of the so-called receiving types and certainly would not cost over five dollars. This is a case, therefore, where the amount of tube business involved is negligible, particularly as the industry and operation covered by this electronic application could not possibly require more than a relatively few equipments.

The rat trap described in the second item would undoubtedly catch rats and might be technically satisfactory. However, in spite of "the better mouse trap" quotation credited to Ralph Waldo Emerson, it is certainly not going to be true of this inventor that "the world will make a beaten path to his door." This is a case of an electronic application which is simply way out of balance economically. Electron tubes can and do accomplish wonderful things, but electronic equipment cannot be sold and stay sold on the glamour or publicity value of the job it is intended to do or the mere fact that it is electronic.

The third case is typical of how mass advertising and publicity have impressed the layman with the unlimited possibilities of electronics.

Wartime Phenomena

Admittedly, these are somewhat extreme examples, but to a lesser degree they have appeared hundreds of times in print over the last few years. They must have caused many men and concerns to look into the future business possibilities of electronics, particularly the manufacture and sale of electron tubes, the heart of such devices.

During wartime the manufac-

method is to consider as a basis the best prewar year. This is unquestionably the year 1937. During that year of good business, there was a big volume of sales resulting from the more than five years of depression-deferred buying. That this was a good year for American business in general is well established by the business indices. That it was a good year for electrical manufacturers in general and tube manufacturers in particular is borne out by the figures in the following table, showing the common stock per share earnings of a number of leading producers in the field:

	1935	1937	1939
General Electric	$0.97	2.21	1.43
Hygrade Sylvania	3.31	3.58	3.52
KenRad	1.49	2.31	(d) 0.25
Raytheon	(d) 0.15	0.46	(d) 0.48
RCA	(d) 0.03	0.42	0.35
Westinghouse	4.50	7.66	5.24

(d)—*deficit.*

It is very apparent from the above that 1937 was a peak year in comparison with either 1935 or 1939. The year 1937 is also a good one to study because the U. S. Department of Commerce Biennial Census of Manufactures covers 1937 as well as 1935 and 1939. The following table, using figures from the census reports, shows for these three years the dollar volume of electron tubes at the manufacturers' selling price:

	1935	1937	1939
Receiving	$28,975,216	$39,250,558	$32,946,740
Transmitting	1,874,458	3,004,569	2,267,856
Trans. Rect.	712,472	542,099	360,674
Phototubes	1,004,799	190,043	170,110
Industrial		935,109	2,317,080
	$32,566,945	$43,922,378	$38,062,460

Note: *The 1939 figures for industrial tubes are believed to include tubes for therapeutic high-frequency equipments which were included with transmitting tubes in* 1935 *and* 1937.

As noted above, the dollar figures given in this article are, as defined in the U. S. census reports, "selling values at factory or plant." For merchandised tubes, therefore, there is a large spread between this figure and list price. On the other hand, for small lots of industrial tubes sold direct, the figures may be the same as list price.

A certain amount of estimating and rearrangement of figures is necessary in comparing these years because the classifications covering the period are not uniform. Another factor, often neglected, which leads to an over-optimistic picture of the volume of tube business, is the ratio between the cost of the tubes in a complete piece of electronic equipment and the total cost of the equipment. For transmitters and receivers the census report for 1937 indicates a ratio of about 15 percent. In the case of industrial and most other types of equipment using tubes, the percentage is even lower. Therefore, the total business in electronic equipment may well be nearly ten times the tube business.

Using the 1937 figures as a basis, let us study each of the fields in which tubes were used in an attempt to gage the tube business in the immediate postwar years and also to make estimates for newly developed uses. Possible changes in cost and price levels cannot be taken into account, of course.

In any estimates on postwar business, it is necessary to define the time element as carefully as possible. The estimates that follow are based on the probable amount of available business per year for the first two or three years after present large-scale war-need manufacture no longer exists. In applications employing receiving tubes, the new sockets that will add to the demand for tubes can be created in a few months. The same is true of tubes used by amateurs and experimenters. On the other hand, the largest sizes of sealed ignitrons are used with power conversion equipments that require a year or more to engineer, build and install. In this latter category also come new applications like ultra-high-frequency relaying, where much research and experimental work must be done, plus accumulation of some actual operating experience, before large-scale manufacture gets underway. Therefore, in some cases, factors like those mentioned above may indicate a relatively low average level for the first three years, even though longer-term prospects are encouraging.

Another factor that must be kept in mind in studying the probable postwar electron-tube business is an increase in the number of producers. This is referred to later in connection with certain of the classifications. Also, in the case of most of the prewar manufacturers in the field the facilities available for tube manufacture have of necessity been enormously increased since 1937.

Receiving Tubes

The census reports show the number of receiving tubes produced as follows:

1935	78,231,142
1937	112,218,139
1939	109,520,893

In 1937 practically all the receiving tubes made in this country came from ten manufacturers.

The War Production Board recently released figures giving the 1944 receiving tube requirements as 144,000,000 and the 1945 requirements to be met as 180,000,000 units. Practically all of the 1944 production came from eight manufacturers. It is very evident that the huge, many-fold wartime expansion in the electron-tube business was mostly in types not in the receiving tube classification.

The postwar readjustment problem is least serious in the case of receiving tubes. There is reason to hope that present unit volumes may be pretty well maintained, and a $63,000,000 receiving tube business is a good probability. This is based on an assumption of 35 cents per tube, which is arrived at from the census statistics. Television and f-m broadcasting for the first few years can be expected to add only about 10 percent to this figure (excluding picture tubes). This gives an estimated total of $69,000,000 in round figures.

Another factor that must be taken into account in connection with the postwar receiving tube business is the continued trend toward organizational set-ups incorporating both receiver and receiving tube manufacture. Thus the business available to concerns making only receiving tubes may be relatively smaller than prewar. Obviously, more receiver manufacturers may decide to make their own receiving tubes.

The number of receiving tubes purchased by such users as amateurs, the Government, communication companies and the emergency service, although amounting to possibly several hundred thousand tubes a year, is hardly a factor in

comparison with many millions used for broadcast reception.

Transmitting Tubes

Transmitting Tubes for Television and A-M and F-M Broadcasting—It is in radio transmitting tubes that the enormous war expansion in tube manufacture has taken place. In 1937 ten manufacturers made practically all the transmitting tubes used. Today this number is just about double.

The chief factor that has swelled the total for World War II is the very large number of special and new designs of high-cost tube types for military applications. For these tubes the usual ratios of dollars-per-kilowatt-output per-year-of-operation are much higher than the prewar figure. In some cases the results obtained can support the high cost in commercial applications, but in many others it will be prohibitive.

FCC reports indicate that on January 1, 1937, there were 685 broadcasting stations and this figure had increased to 721 at the end of the year. Thus the average in operation during 1937 may be considered as 700 for a round figure. In February of 1945, there were 912 a-m broadcasting stations in operation. In addition, as regards f-m, the situation at the opening of the year 1945 was:

46 operating
7 under construction or soon to be constructed
353 applications on file with the FCC

This gives a total of 406 stations that may be in operation during the early postwar years.

As regards television transmitters, there are nine now in operation and 108 applications on file with the FCC, making a total of 117 possibilities for the early postwar years. As each television station really contains both an audio and video transmitter, these may be considered as 234 transmitters for addition to the a-m and f-m units. Thus for the early postwar years, there is the probability of 912 a-m, 406 f-m and 234 television transmitters or a total of 1552 transmitters. This is slightly over double the number of transmitters operating in 1937.

There are some factors tending to lower the tube maintenance cost in transmitters and some which increase it for the postwar period in comparison with the year 1937. It must be remembered, however, that less than half, or about $1,700,000 of the 1937 transmitting tube total went to broadcast transmitters. The remainder was sold for use by the government, amateurs and communication transmitters as well as other classifications. Therefore, a doubling of volume, say to $3,400,000, seems a reasonable postwar estimate.

Government Radio and Radar—Although it is doubtful whether the government will purchase very large quantities of transmitting tubes in the immediate postwar era, there will undoubtedly be a great deal of developmental activity and the building of a limited number of trial equipments for a wide variety of applications. It must be kept in mind, however, that there are enormous stocks of standardized tubes now being accumulated.

In 1937 the government business in radio transmitting tubes was probably about $500,000. Doubling this figure, on the basis that radar has been added, and then trebling it for increased activity, a $3,000,000 business in this field (excluding development) would seem to be an ample estimate. It must be remembered that in 1937 the sale of such tubes was included in the totals given for transmitting tubes.

Power Tubes for Transoceanic, Marine and Other Toll Radio Communication—Tubes for this use were included in the 1937 total. To a considerable extent, the companies using such tubes either manufacture them directly or through subsidiary companies, and therefore such business can hardly be considered as generally available. A total figure of $250,000 per year would certainly cover the field. Surplus government stocks might well supply much of this demand for several years.

Aids to Marine and Aircraft Navigation—This is almost wholly a new field since 1937. Developments in radar will undoubtedly provide numerous applications. However, unlike the war applications of radar, peacetime applications would appear to be very largely for short distances and of low power, indicating that the great majority of tubes will be small transmitting types. Assuming 1000 commercial aircraft and 6000 U. S. merchant vessels, an estimate of $700,000 would appear to be ample for this field.

Aviation Communication—Here the great question is the number of personally owned and operated planes that will be in use, plus an added estimate as to what proportion of these will have radio communication. The CAA has estimated 210,700 such planes after the war[3]. Other estimates have differed widely and mostly downward from this figure. If such communication units do come into use to anything like the extent indicated by the CAA estimate, then a whole new communication system, including ground stations, will have to be set up. In general the great majority of such equipments would be low power, including those on the ground and, therefore, the transmitting tube cost per unit would be rather low. In view of the time required to build up this business, a tube volume estimate of $1,000,000 per year for this field for the early postwar years would appear to be ample. This would include tubes for the transmitters of commercial airline planes and their base stations.

Mobile and Emergency Use—Included under this heading are not only some well-established applications but also recently enlarged or suggested services such as those used by:

Railroads and car ferries
Fire departments
Forest and conservation agencies
Public utility companies
Bus, truck and taxicab fleets
Highway departments
Special commercial operations, such as lumbering, quarrying and large-scale outdoor construction

In such applications as municipal and state police, probably the field is 50 percent to 75 percent saturated. On the other hand, the use of radio in connection with the dispatching of taxicabs, of which there are approximately 48,000 in the U. S., is practically untouched. It is to be remembered that for such equipment relatively small transmitting tubes are employed. Certainly a $750,000 annual business is

an ample estimate for this classification.

Radio Relay Equipment—This is another new application and it is impossible to predict the rapidity with which it will grow or the extent to which it will grow. Again, however, the transmitting tubes used are of the low-power variety selling for $5 to $20 each. A total of $500,000 a year is certainly optimistic for this classification.

High-Frequency Induction and Dielectric Heating—Tubes for such service are included in the classification of transmitting tubes because they are so similar in their general ratings and sizes. If high-frequency heating is to be commercially successful and is to attain any large volume it is absolutely necessary that the tubes have a very long operating life. Replacements, considering a three-year life and an average of two tubes per equipment, would be approximately 700 tubes per year per 1000 equipments. Let's assume that in addition about 300 tubes would be used for installation in new equipment, making a total of approximately 1000 tubes per year. This represents a production of approximately four tubes per working day and, assuming an average figure of $100 per tube, there results a business of $400 a day. In this estimate the five-day working week has been assumed and, taking holidays into account, this means about 250 working days per year. This would represent a business of approximately $100,000 a year per 1000 equipments in use, plus the 300 tubes estimated as the initial complement in new equipments. It would certainly be an optimistic estimate to triple these figures, giving a total of $300,000 a year in tube business. Of course, it is possible that some new development in this field might result in a demand for a very large number of small units, but in this case the tube cost per unit might be only one-tenth that given above. In this classification, government surplus stocks may also be a factor.

Medical Field (Excluding X-Ray)—In this classification there are included only tubes of the radio transmitting type used to supply high-frequency output for such applications as heat therapy, cautery and electro-surgery. During the years 1935 to 1940, many hastily designed and none-too-well-built equipments were sold to doctors, hospitals, health institutes and gymnasiums. Today, probably more of these early equipments have been scrapped or are standing idle than are being used.

This business now is on a much firmer foundation as regards both its usefulness and design fundamentals, but it may be many years before the yearly business in tubes for this field gets back to the dollar volume of the best of the boom years. This broad field, however, still continues to show promising medical results and does constitute a worthwhile tube business. However, the more rational viewpoint now taken of its applications means that it is not going to require a huge supply of tubes. It would certainly seem that an estimate of $500,000 per year is ample.

Diagnostic equipment, such as the electrocardiograph, electronic stethoscope and the electroencephalograph, is going to be important and may well represent a rather large total of equipment business, but the tubes used are of the receiving type and their dollar volume is included in that classification.

Amateurs and Experimental—For 1939, sales of all transmitting tubes under the 50-watt rating totaled $272,128 and rectifier tubes under the 10-kv rating totaled $178,837. For 1937, the nearest comparable classification included tubes ranging from 5 to 250 watts in size and the total value was $1,520,256. The figures for rectifier tubes are even less informative in this field. On the basis that half the 1939 output noted above went to amateurs, plus an equal dollar volume of tubes in other classes, and that 1937 was a good year and 50 percent higher than 1939, the total reaches $700,000 as a rounded topside figure which would appear to be a satisfactory postwar figure to use.

Tubes of the So-Called Industrial Type

In 1937, there were five tube manufacturers that built the great majority of industrial tubes. In 1944, there were at least 12 comparable tube producers in the field.

Thyratrons—Such tubes, particularly in the smaller sizes below the rating of ½ ampere, will be used in relatively large quantities in industrial applications. The life will have to be long for acceptance and probably for a number of years to come the new-equipment market for tubes will far exceed the replacement market. This business amounted to about $350,000 in 1937, but it might well reach a yearly total of $1,500,000 in the early postwar period.

Sealed Ignitrons for Industrial Control—This field has expanded tremendously in the past five years and many of the tubes and items of equipment now used for war can be converted to peacetime production. A total of $750,000 per year would appear to be an optimistic estimate.

Ignitrons for Power Conversion—Here the picture can be likened to a certain extent to high-frequency heating in that a very long tube life is required. By the end of the war, there may be something like 2400 sockets in service. On the basis of a three-year life, this represents a renewal figure of approximately 800 per year, which corresponds to a requirement of about three tubes per working day. This field, particularly in the higher power sizes, is much nearer a saturation point than is the case for high-frequency heating. Let's assume that five tubes per day, or 1250 tubes per year, would take care of the demand, including new installations. At an average figure of $200 per tube, this represents a business of $250,000 per year.

High-Voltage Rectifiers

High-voltage kenotron rectifiers are used for such applications as dust precipitation, cable testing, paint spraying and paint de-tearing. This business amounted to only about $10,000 in 1937. Certainly an estimate of $50,000 is ample for a postwar year. There is always a possibility, of course, that some new application in the chemical or petroleum industry will create a large demand for tubes of this type but how soon such a demand would build up and the number involved cannot be subject to any real estimating.

Photoelectric Tubes

The best prewar year for photoelectric tubes was 1937, with a total business of $190,000. There is reason to believe that this will steadily increase and, therefore, an estimate of $250,000 does not seem over-optimistic.

In 1937, there were four active manufacturers; today there are at least six.

Cathode-Ray Tubes

The two chief uses for cathode-ray tubes are in oscilloscopes and in the field of television. It seems very improbable that for at least a few years to come television receivers will be sold under an average figure of $150. U. S. census figures indicated sales of 5654 radio-phonograph combinations costing over $150 in 1939, which for these units was a better year than 1937. Of course, a television receiver gives the purchaser more potential entertainment. In general, however, the number of individuals in television-served areas who will purchase equipment of this sort at a figure of several hundred dollars is definitely limited. Assuming a figure of 50,000 cathode-ray tubes for television receivers and 20,000 for instrument use, or a total of 70,000, and a figure of $15 each, we get a total of around $1,100,000.

In 1937, there were only two manufacturers who made these tubes in quantity. Today there are at least ten.

Miscellaneous

Miscellaneous applications include such items as battery-charging tubes, regulator tubes, indicator tubes, tubes for ionization gages, ballast tubes, automatic train-control tubes and many others used in relatively small quantities. A total of $1,000,000 would be a fair estimate for this group. (Telephone repeater tubes and x-ray tubes are not included in the scope of this article.)

Under this general heading of miscellaneous, one might well ask what of the many tens of thousands of vacuum tubes that are going to be used in the myriad of ingenious devices that have been described over the past few years. The answer appears to be that while it is true that there will be tens of thousands and maybe hundreds of thousands of these applications, well over 99 percent of them will use only standard receiving-type tubes and the number so used is very small in comparison with those sold for use in home radio receivers.

The Export Field

The census figures for the prewar years included tubes exported. The question arises, therefore, to what extent the percentage of tubes manufactured during the early postwar years for export will exceed the prewar percentage figure. There are high hopes that this percentage will increase markedly. To offset this, however, it is probable that the war surplus stocks of tubes will be found particularly suited for use in this field.

The Time Element

In any series of estimates, such as in this article, one of the biggest uncertainties is the time element. Certain uses will develop more quickly than others. We have attempted here to arrive at some figure applicable to an early postwar year.

The total output of vacuum tubes in the U. S. over a period of prewar years has shown a fairly steady growth and there is no reason to believe that this normal growth has approached saturation or even that it has reached its maximum rate of growth. The whole question is: To what level will the business drop before resuming its steady growth after the war demand has been terminated?

In emphasizing the importance as well as the uncertainty of the time element, the following quotation from an address by Willard Chevalier of the McGraw-Hill Publishing Company seems most apt:[3]

> "The very mention of the word 'electronics' lays open a vast field for speculation as to its particular part in the broader program for technology in the postwar world. Unfortunately crystal gazing has its disadvantages. The prophet who looks into his globe and sees electronics doing most of the work of the home and the factory of the future should have another crystal ball handy into which he could peer and determine the date upon which these developments will be available to the customers."

Recapitulation

The following table brings together what may be termed optimistic figures given in the preceding paragraphs:

Receiving Tubes	$89,000,000
Transmitting Tubes	
Television, F-M and A-M Broad.	3,400,000
Government Radio and Radar	3,000,000
Transoceanic, Marine, Toll	250,000
Aids to Navigation	700,000
Aviation Communication	1,000,000
Mobile and Emergency	750,000
Radio Relay	500,000
High-Frequency Heating	300,000
Medical Field	500,000
Amateur and Experimental	700,000
Industrial Tubes	
Thyratrons	1,500,000
Ignitrons for Control	750,000
Ignitrons for Power Conversion	250,000
High-Voltage Rectifiers	50,000
Photoelectric Tubes	250,000
Cathode-Ray Tubes	1,100,000
Miscellaneous	1,000,000
	$85,000,000

No figures have been released on the total production of electron tubes in the United States during the past few years. However, the WPB has released figures on total production of military items of communication and electronic equipment for 1940 to 1944, inclusive. For 1943 and 1944, the yearly average was $3,000,000,000 or over. On the basis that 10 percent to 15 percent of this volume represented tubes (including, of course, the high ratio of wartime spares) this would give a total tube production approaching $400,000,000.

EDITOR'S NOTE: *Since this paper was written, the WPB has released figures on electron-tube production for 1944. It shows a grand total of approximately $406,000,000, which is close to the author's estimate.*

If receiving tubes are subtracted from this total, there would remain at least $300,000,000 for all types as compared with the $16,000,000 volume estimate for a postwar year. This may seem like a tremendous decline but if compared with the corresponding figure of a little under $5,000,000 for 1937 it represents a pretty healthy rate of growth.

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Wire Splice Detector

Steel wire is magnetized by passing it between the poles of two magnets. The magnetic poles created at discontinuities trigger an electronic circuit when the wire is passed through a detector coil. Aural and visual indications are given

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THE SPLICE DETECTOR to be described utilizes magnetic poles created at splices in steel wire to operate an audible and visual alarm.

The wire under test is magnetized longitudinally by passing it through a strong magnetic field. It is then passed through a detector coil in which voltages are generated by the motion of the magnetic poles produced at the discontinuities. The voltage thus generated is amplified and impressed upon a thyratron trigger tube which operates a buzzer, giving an audible signal. The buzzer is also connected to a telephone receiver, which allows the signal to be heard in noisy locations. A visual signal is provided by a cathode-ray tube.

The sensitivity of the apparatus is such that it is possible to detect a single-strand splice in paired wire containing a total of 14 steel strands.

General Description

The apparatus which makes up the splice detector is shown in Fig. 1. The magnet assembly, through which the wire is passed first, is shown on the right of the photograph. The coil which responds to magnetic discontinuities in the wire is shown at the left.

The detector apparatus is shown in the center of the photograph. Connection to the 115-v 50-60 cycle a-c supply is made at the left end of the box. The telephone set is plugged in on the right side. The detector coil is connected at the right rear. The control on the left of the front panel is the power switch. Next to it is a switch used for restoring the circuit to normal after the gas tube is triggered. The indicator tube is mounted so that it is visible through the circular window at the center of the panel. The sensitivity control for the detector is at the extreme right on the front panel. This control, designed for screw-driver operation to prevent accidental changes in adjustment, determines the triggering point of the gas tube. The screwdriver control next to the sensitivity control is used to adjust the shadow angle of the indicator tube.

Field wire may now be laid from an airplane by means of apparatus such as this, shown being installed in an Army C-47. The splice detector is particularly valuable in checking such wire, since discontinuities are frequently masked by insulation

The magnet assembly consists of two horseshoe magnets having very high field strength. They are held against a square brass bar, with the two north poles facing each other. The wire passes through a $\frac{3}{8}$-in. longitudinal hole in the bar. The small size of the hole insures uniform magnetization of the wire. Its length prevents sidewise motion near the magnetic poles.

The detector coil consists of 2500 turns of wire wound on a wooden spool, having a $\frac{3}{8}$-in. hole in the core for passage of the wire. The minimum dimension of the coil is such that the turns can be placed in close proximity to the wire which passes through. The coil is made sufficiently long to prevent voltages being generated due to whipping of the wire. The coil mounting is made of wood.

Circuit Details

A schematic diagram of the detector circuit is shown in Fig. 2.

Volatges due to irregularities in the wire, generated in the detector coil, are fed into a two-stage voltage amplifier utilizing tubes VT_1 and VT_2. The amplifier output operates a thyratron trigger tube, VT_3, which operates a buzzer through a relay.

The circuit constants of the amplifier were selected to obtain maximum gain consistent with good performance at the frequencies normally encountered, and to obviate the need of screen bypass capacitors. Excellent stability is achieved. Filtering is employed in the input circuits of each stage to attenuate high-frequency voltages picked up in the coil. It has been found that minute magnetic irregularities in the wire cause such high-frequency voltages to be generated, and these voltages might trigger the thyratron were it not for the input filters.

The normal frequency of an impulse generated at wire splices is 10 to 30 cps, depending upon the

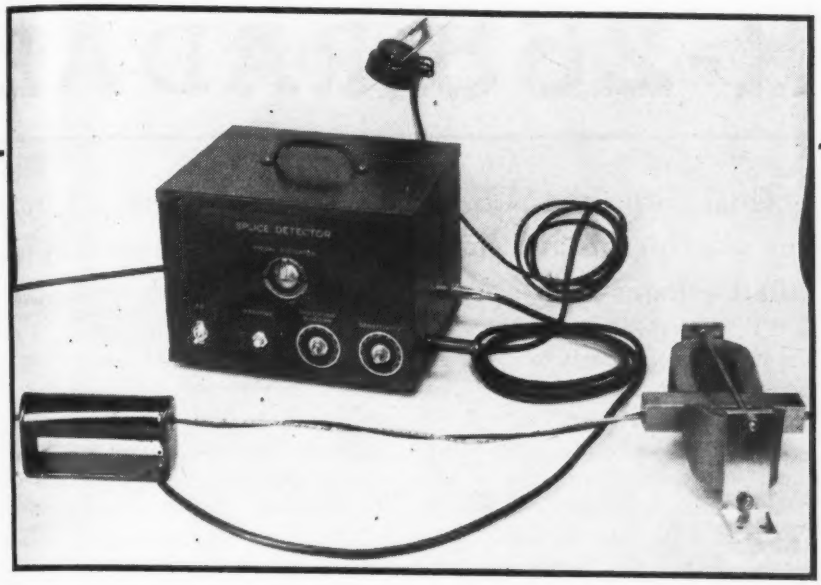
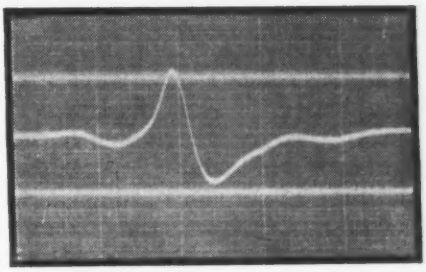


FIG. 1—The equipment, complete with built-in power supply. The magnetizer is at the right, the detector coil at the left and the amplifier-trigger-indicator unit at the center. Single-strand splices in paired wire containing a total of 14 steel strands are readily located



Oscillogram showing the nature of the amplified pulse produced when a lapped splice passes through the detector coil

speed of the wire as it travels through the coil.

The thyratron detector is a gas tube. The plate-circuit d-c relay operates on 10 milliamperes. Resistor R_1 is placed in series with the relay winding to restrict the plate current of the thyratron to the limits of the relay winding, the tube and the power supply. There is also a normally-closed switch *SW* in the plate circuit, the operation of which will restore the trigger circuit after the tube has operated. The sensitivity control P_1, in the trigger tube input circuit, permits the bias on the grid to be varied through a range of 0 to 12-volts negative, for close adjustment of trigger action.

A visual signal is obtained through the use of the indicator tube VT_4, which is connected to the output of the amplifier in parallel with the trigger tube. The shadow angle, which varies to indicate voltage changes, has a sensitivity adjustment from 0 to 20-volts negative, through P_2.

Transformer T has a center-tapped high-voltage secondary rated at 650 volts, 40 milliamperes. Two gaseous type regulator tubes VT_6 and VT_7 are connected in series across the output of the rectifier tube VT_5, and maintain a substantially constant potential of 210 volts. The filtering resistors R_2, R_3 were selected so that the current through the regulator tubes, with the plate circuits to the test set disconnected, was approximately 30 milliamperes. It is essential that the voltage regulators be operated near their maximum rated current with minimum load current on the set.

Operation

When using the splice detector, it is essential that the magnet be placed in line with the coil and separated from it by approximately three feet, in order to prevent stray magnetic fields from influencing the coil. It is also necessary to polarize the magnet and the coil properly. The magnets and the coil should be so related that the initial voltage generated in the coil will impress a positive voltage on the grid of the trigger tube, thereby reducing the negative bias on the grid and causing it to fire. The time constants of the circuit are such that if the negative half-cycle of the voltage is impressed first, the full effect of the succeeding positive half-cycle is not realized and the circuit is less sensitive and unreliable in operation.

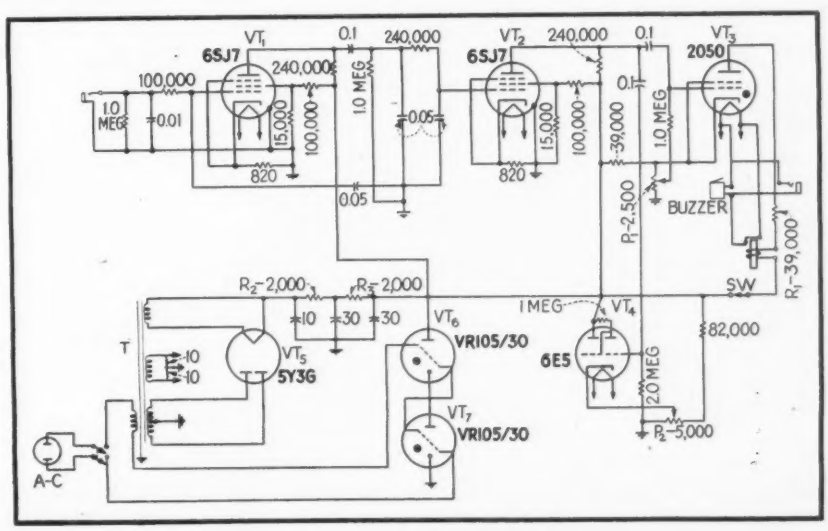


FIG. 2—Circuit of the splice detector

The SCR-268 RADAR

Developed before the war by the Signal Corps, the SCR-268 has seen service on all fronts detecting enemy aircraft, directing searchlights and guns toward them. Surpassed in performance, and captured by the Germans and Japanese, it may now be described

ON THE EVENING of May 26, 1937, Mr. Harry Woodring, the Secretary of War, stood with a group of officers and civilian scientists on a field of the Signal Corps Laboratories at Fort Monmouth, New Jersey. Before them, spread over the field, were the transmitter and receivers of a radio detector, the SCR-268 prototype. Connected with the radar were the controls of a standard anti-aircraft searchlight.

As prearranged, an Army aircraft flew over the field in the darkness. Three enlisted men, viewing oscilloscopes, put the radar "on target" and tracked it across the sky. When tracking was established, the command was given to light the searchlight. As the light pierced the darkness, the aircraft, caught in the beam, became visible to those on the ground.

The next day, orders were given to move the equipment to a remote corner of Fort Hancock, where secrecy could be better preserved. In the eight years that have intervened, secrecy has been the watchword of radar development. But in November 1944, the SCR-268 was reduced in classification from "confidential" to "restricted". By that time, the equipment had been captured, with crews and instruction books, by the Germans and the Japanese. Moreover it had been far surpassed by later radar equipments. While still in use, the 268 was obsolescent, almost antique.

When the editors of ELECTRONICS first approached Signal Corps authorities for permission to describe the SCR-268, they were asked "Why do you want to describe that set?" The answer, not obvious to those working in the radar field, is that the greater part of the electronics industry has never seen a radar set, or a technical description of one, in any form. The SCR-268, by virtue of its early development and wide employment in the war, is not only a significant milepost in radar development, but the first radar to reach such a venerable position that describing it would offer no aid or comfort to the enemy.

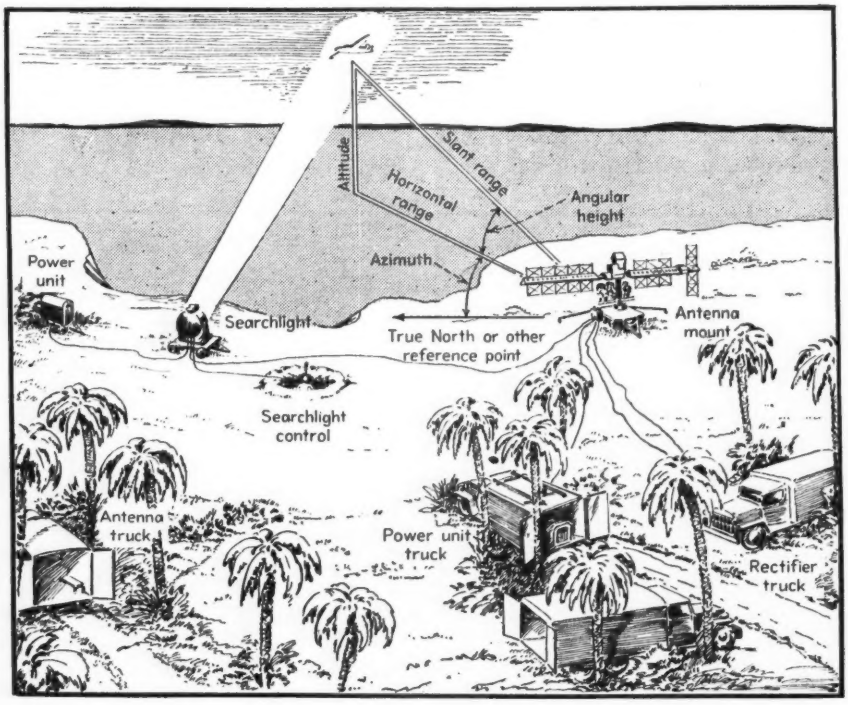


FIG. 1—Artist's sketch illustrating a typical setup, including power supply and transporting trucks

Basic Elements

A radar detects the presence and position of objects by means of reflected radio waves. In the case of the SCR-268, the "object" is ordinarily an aircraft, and the radio waves are projected in sharp bursts or "pulses" at a rate of 4098 per second. A pulse is transmitted every 244 microseconds. Each pulse is of extremely short duration, approximately six microseconds. Between pulses, there is a period of about 240 microseconds during which the radar receivers may detect the echoes reflected from the target aircraft.

When the radar detects a target, the position of the aircraft is indicated in three coordinates, known as the slant range, the elevation (or angular height), and the azimuth. The slant range is the distance from the radar to the target. The elevation is the vertical angle subtended at the radar by the target and the ground plane. The azimuth is the horizontal angle subtended at the radar by the target and true north. The target coordinates are illustrated in Fig. 1.

The radar measures the range of the target by timing the interval between transmission of a pulse and reception of the echo. Since radio waves travel at a velocity of 0.186 miles per microsecond, for each microsecond in the interval the wave travels 0.186 miles round trip from radar to target and back. Accordingly, the distance to the target is 0.093 miles for each microsecond

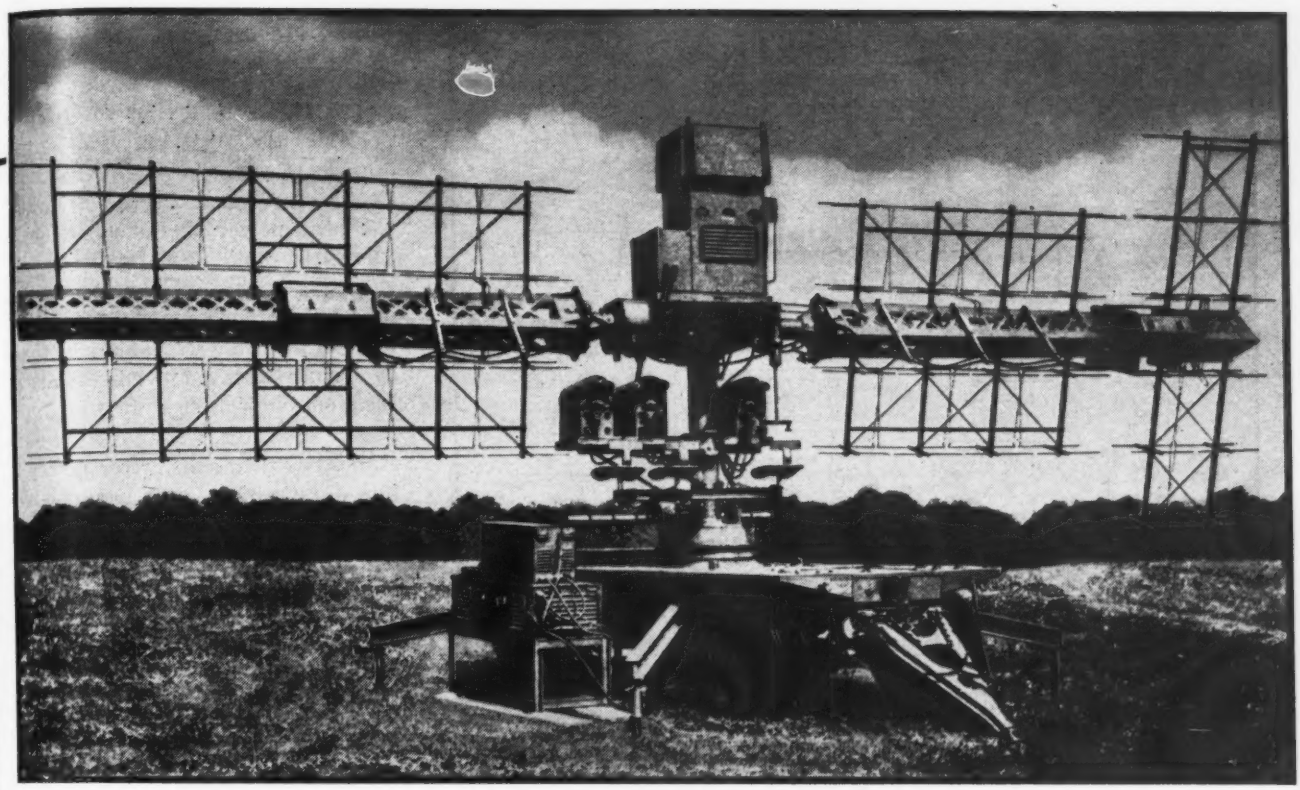


FIG. 2—The SCR-268 radar, seen from the back or control position, showing the azimuth receiving array at the left, the elevation receiving array at the right and the transmitting array in the center

in the interval. If the measured interval between transmission and reception is 100 microseconds, the range of the target is 9.3 miles. The maximum interval which can be accommodated is the interval between pulses, or about 240 microseconds. Consequently, the maximum detection distance, as determined by the pulse interval, is 0.093 x 240 = 22 miles. Sufficient power in the transmitter and sensitivity in the receivers are provided to produce a discernible echo from an aircraft at this distance.

The azimuth and elevation angles are measured by noting the angles at which the receiving arrays are pointed with respect to true north and the ground plane as the target is observed. In the SCR-268 two directive receiving aerials are provided, the azimuth and elevation arrays. The reception pattern of the azimuth array is a fan-shaped figure with a long vertical axis. The pattern of the elevation array is similar, but rotated through 90 degrees, that is, the long axis is horizontal.

The target information gathered

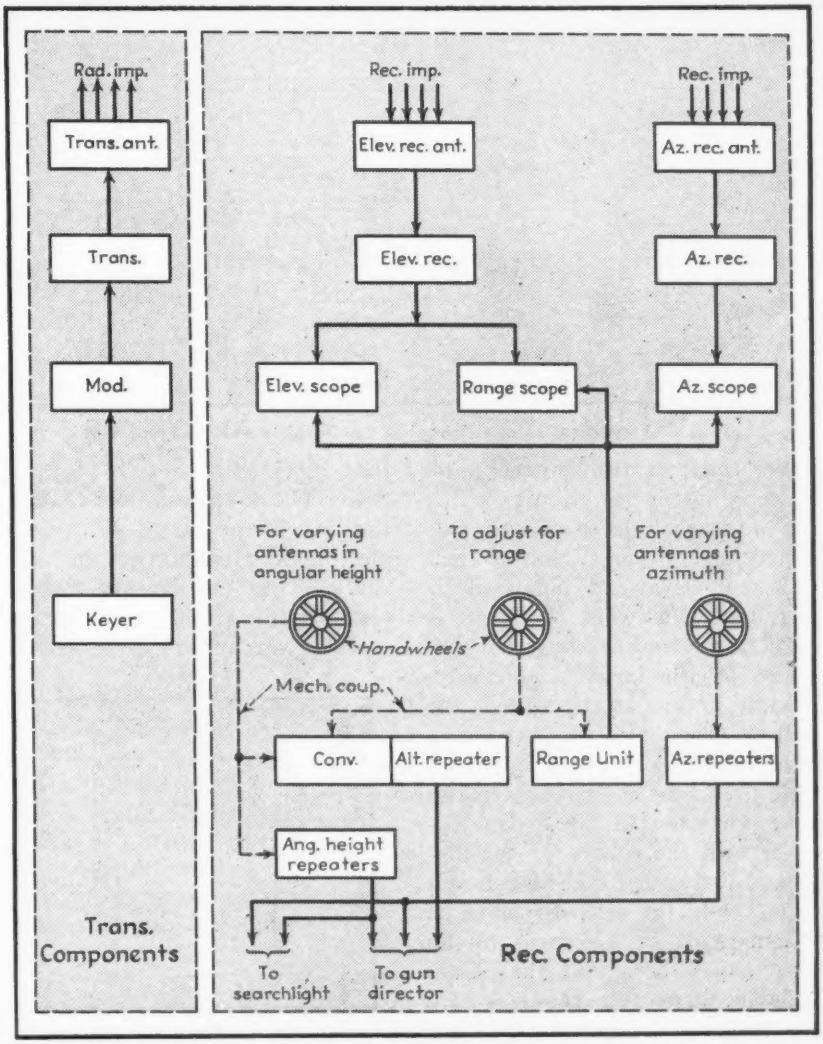


FIG. 3—Simplified block diagram showing basic components of the equipment

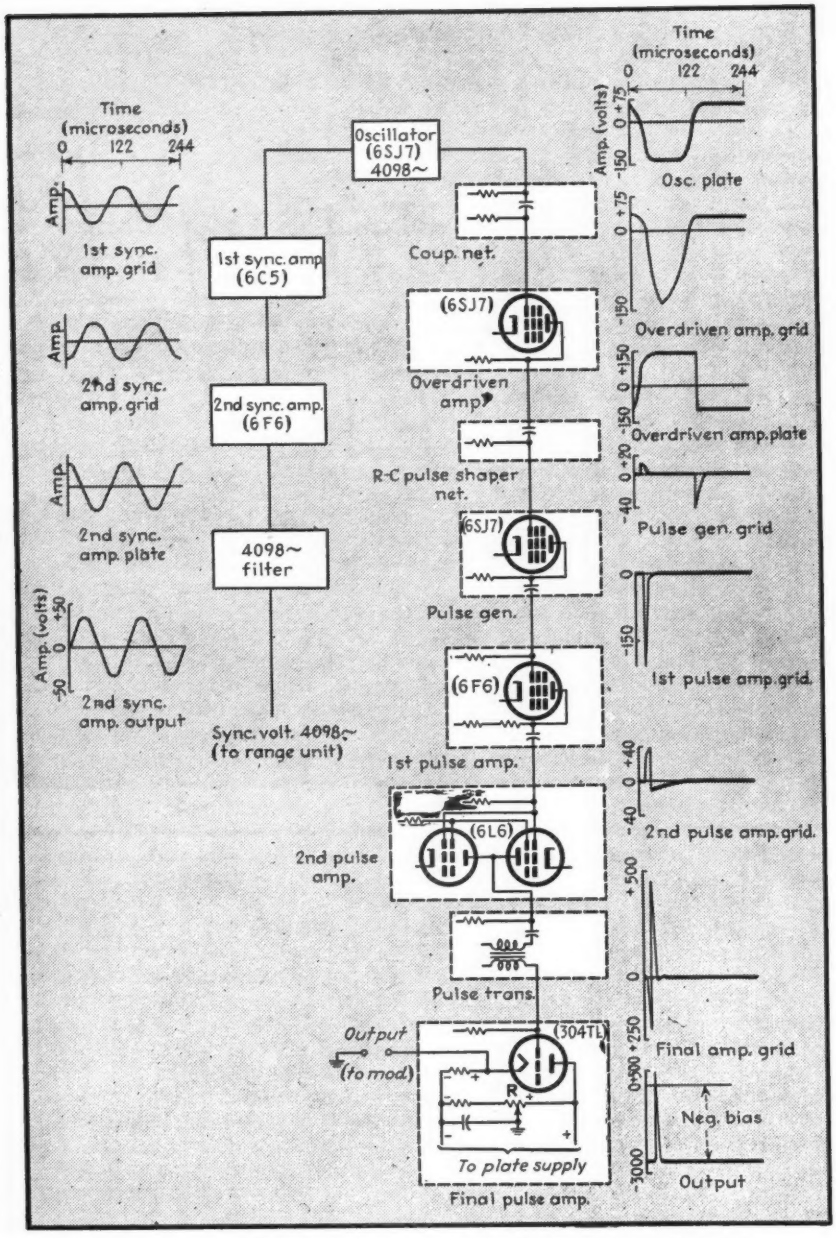


FIG. 4—Functional block diagram of the SCR-268 radar keying unit

by the radar is transmitted automatically to control circuits which keep the searchlight or anti-aircraft gun trained in the direction (azimuth and elevation) indicated by the radar. Thus when the radar is on the target the searchlight or gun is also on the target and can illuminate or fire at the will of the artillery officer.

The reflection of radar signals is a highly inefficient process.[1] The power radiated in the pulse disperses with the square of the distance as it travels to the target, and the power in the echo disperses at the same rate as it returns to the radar. It follows that the power available to actuate the receivers falls off as the fourth power of the distance to the target. This means that an increase of 16 times in power (12 db) is required to double the maximum range of a radar viewing a given target in empty space. Thus an aircraft which is easily visible at 5 miles, using moderate power and receiver sensitivity, may be completely invisible at 20 miles.

This reasoning points to the necessity of employing the highest possible power in the transmitter and the greatest possible sensitivity in the receiver. In the SCR-268, the peak power of the pulses is 75 kilowatts, and the receivers are sensitive to a signal power of 0.1 of a micromicrowatt (10^{-13} watt). Judged by pre-war standards, these are remarkable achievements at the frequency (205 mc) at which the radar operates. But by present standards the transmitter power is not outstanding, and the receiver performance is poor. Nevertheless, the power and sensitivity are adequate to detect aircraft at distances up to 22 miles, provided the aircraft is not too close to the horizon.

General Description

The SCR-268 is pictured in Fig. 2. The radar components are mounted on a trailer. In addition, four large trucks are required, one supplying primary power, another supplying high voltage for the transmitter, and two for the transportation of the radar components.

The trailer consists of a rotatable pedestal which carries three antenna arrays. From left to right as seen from the back of the equipment, these are the azimuth receiving array, the transmitter array, and the elevation receiving array. Behind each receiving array is the corresponding receiver. Atop the pedestal is the transmitter. Directly below the transmitter are three oscilloscopes, with bucket seats in front of them. Here the three operators observe the azimuth, elevation and range, turning handwheels which keep the radar pointed at the target. The handwheels are con-

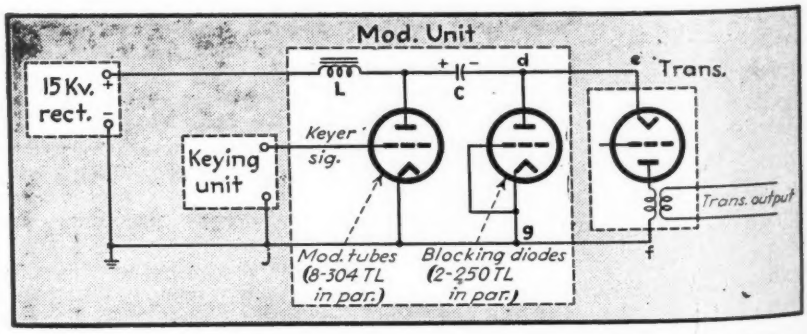


FIG. 5—Simplified schematic of the modulator, which produces wave forms shown in Fig. 6

nected also to the converter which transmits the target coordinates to the associated searchlight control or gun director. On the ground beside the trailer are the keyer and modulator units which drive the transmitter.

The SCR-268 weighs 82,315 pounds, complete with all auxiliaries and trucks. It consumes 15 kva of power. Despite these large figures it can be (and has been) set up and ready for operation within a few hours of being put ashore at a beachhead.

The block diagram, Fig. 3, shows the flow of the signal through the equipment. At the left are the transmitter components, which comprise a separate group. The keyer establishes the basic timing of the transmitted pulses at 4098 per second and produces the short (3 to 9 microsecond) pulses which drive the modulator. The modulator raises the power level of the keyer output and applies modulating pulses to the transmitter. The transmitter is a self-excited tuned-plate tuned-grid oscillator consisting of 16 tubes in a ring circuit. The transmitter output is applied to the transmitting array, which radiates a beam of circular cross section approximately 10 degrees wide.

When the transmitted beam encounters a target, the echo is returned to the two receiving arrays. The directivity of these arrays is about 12 degrees in the azimuth array and 9 degrees in the elevation array. By means of receiving antenna "lobe switching", to be described later, the directivity in azimuth and elevation is refined to about ±1 degree in each coordinate.

The signal received by the elevation array is passed to the elevation receiver and thence to two cathode-ray indicators. One indicator displays the range of the target, the other the elevation. Both are "type A" indicators, that is, they are essentially similar to a conventional test oscilloscope. The cathode-ray beam is driven by a sweep circuit at constant speed from left to right. The echo signal from the associated receiver is applied to the vertical deflection plates so that the beam is deflected upward whenever an echo is received. At the left end of the oscilloscope trace the transmitted pulse appears. This establishes the "zero" of the time scale. The distance from the transmitted pulse to the echo, measured on the range indicator, gives the distance to the target, or range.

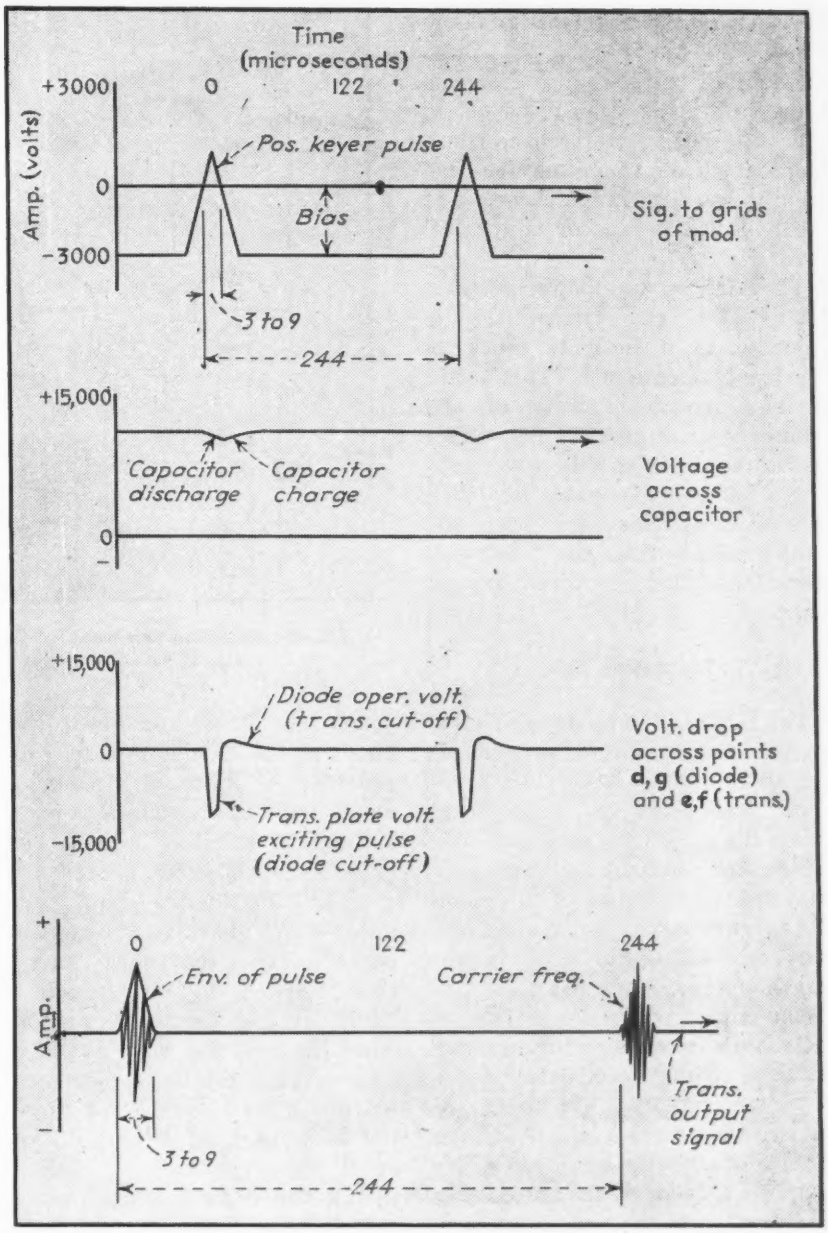


FIG. 6—Modulator wave forms, obtained by means of the circuit shown in Fig. 5

The elevation indicator is similar, except that two echoes are displayed, slightly displaced from one another. The two echoes, known as the "split image", are produced by shifting the directivity pattern of the elevation array slightly, at a rapid rate, by the receiving antenna lobe-switching method. The operator adjusts the elevation array until the two echoes in the split image have the same height. The array is then pointed directly at the target within the one-degree error previously mentioned.

The azimuth receiver is connected to a similar oscilloscope which displays a split image produced by shifting the pattern of the azimuth array. The operator at this indicator adjusts the orientation of the azimuth array until the two pulses in the split image are of equal height. The azimuth array is then pointed at the target within 1 degree accuracy.

The remaining items shown in Fig. 3 are the repeaters and converters which transmit the target information in suitable form to the searchlight or gun director. The principal electronic component here is the range unit, which introduces a time shift in the deflection circuits of the range indicator. When

the operator turns the range handwheel, the radar echo is moved horizontally on the indicator screen. This permits the echo to be placed over a specific reference point, from which the range may be read accurately. The range accuracy of the SCR-268 is plus or minus 200 yards.

The high voltage power rectifier supply for the transmitter is mounted in a separate truck as previously mentioned. This latter rectifier has a capacity of 500 milliamperes at 15,000 volts. Since the output drain on this power supply is confined to periods less than nine microseconds long, with 240 microsecond intervals between them, the filter required is not large.

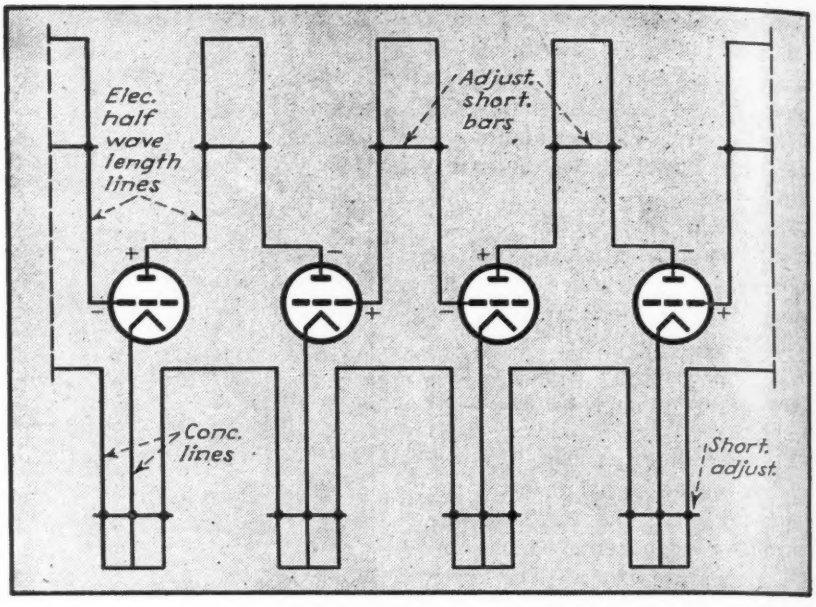


FIG. 7—Simplified schematic of the SCR-268 radar transmitter, showing just four of the sixteen type 100TS tubes used in a ring circuit

The Keying Unit

The heart of the radar is the keying unit, which establishes the basic timing of the system. The keyer must first establish the rate at which the pulses are sent out, 4098 per second. Secondly, it must produce individual pulses of the requisite short duration, and it must prevent any undue variation in the length of successive pulses.

The output of the keyer is used to drive the modulator tubes, which are cut off between pulses by a heavy negative bias. The keyer output is, therefore, a positive pulse capable of overcoming this negative bias and driving the modulator grids well into the positive region. These requirements add up to a formidable total. The keyer must provide an accurately timed pulse of from three to nine microseconds length, and of some 3500-volts peak amplitude. This requirement is met by the use of eleven tubes in the keyer unit, two of which are power supply rectifiers.

Figure 4 is a simplified schematic of the keyer unit. The basic timing element is the 4098-cps oscillator (6SJ7 at the top of the diagram). This is an electron-coupled oscillator of the Hartley type. Two outputs are taken from the oscillator, one intended for the range unit and the other for the keyer proper. The former path consists of two amplifiers and a 4098-cps filter, the output of which is a 4098-cps sinewave of 50 volts peak amplitude. The latter, or keyer, path starts at the oscillator plate, which provides a flattened (non-sinusoidal) wave. This voltage is passed through a coupling circuit (0.01 μf series capacitances, with 100,000-ohm and 50,000-ohm shunt resistance) which sharpens the oscillator output. The sharpened wave is then applied to an over-driven (grid-current limiting) amplifier which flattens the wave again, but by this time the pulse possesses a much sharper leading edge. Following is a peaking circuit of very short time constant (0.00005 μf and 50,000 ohms) which responds only to the leading and trailing edges of the applied wave. The output consists of a small short positive pulse, and a somewhat larger negative pulse which is not thereafter used. These pulses are applied to the pulse generator which is biased to cut-off. It responds to the small pulse, but not to the negative pulse. The output of this stage is a sharp pulse of about -170 volts amplitude.

The remaining portion of the keyer is occupied with increasing the peak voltage of this pulse and reversing its polarity. The first pulse amplifier (a 6F6 beam-power tube) is intended to produce a higher current pulse, without a high voltage output. This current pulse drives two 6L6 beam power tubes in parallel, the output of which is conducted to a pulse transformer, capable of passing very short pulses. The output of the transformer is a double-peaked wave of about 750-volts peak-to-peak amplitude, centered about a point two-thirds up from the negative peak. This wave is applied to the grid of the final amplifier, a 304TL triode. This tube is a high-current thoriated-tungsten triode, consisting of four triode units in a single envelope.

When the pulse arrives at the 304TL grid the tube passes a current of approximately 1 ampere through a cathode coupling resistance, thus producing a pulse of 3500 volts peak amplitude across the output terminals. Since the tube is biased to cut-off, there is no response to the negative peak. Between pulses, when the 304TL is not conducting, its output terminals are connected across the B-supply voltage. One output terminal is some 2500 volts negative (adjustable by resistor R) with respect to ground. This is the bias voltage for the succeeding modulator tubes. The use of the cathode-follower circuit in the final keyer amplifier provides a low impedance output, which permits conducting the short-length pulses over coaxial cables to the modulator unit.

The Modulator Unit

The function of the modulator unit is to amplify the keyer output to a high power level, suitable for

plate-modulating the transmitter (r-f oscillator) proper. Figure 5 shows the simplified schematic.

The modulator tubes (8 type 304TL tubes in parallel) act as an electronic switch, under the control of the keyer. The electronic switch is in series with the storage capacitor C. This capacitor is charged continuously from the high voltage power supply (15,000 volts) through the choke L and the blocking diodes (2 type 250TL tubes in parallel). When a positive pulse is delivered by the keyer to the modulator grids, the modulator plates suddenly conduct. The inductor L impedes any flow from the power supply through the modulators for the duration of the pulse. Therefore, the only source of plate current is the storage capacitor C. This capacitor discharges, during the pulse, through the series circuit composed of the modulator tubes and the transmitter (oscillator) tubes. The resultant sudden pulse of current causes the transmitter to oscillate and it continues to do so while the pulse is applied.

The current passing through the modulator tubes is about 10 amperes, and the voltage drop across them is about 3000 volts. Hence 12,000 volts at 10 amperes passes through the plate circuit of the transmitter. This is a peak input of about 120 kilowatts, of which about 75 kw appears as useful r-f output power.

When the modulators conduct, they form a closed circuit of which the storage capacitance and the series inductance (leads and transmitter tank circuit) are a part.

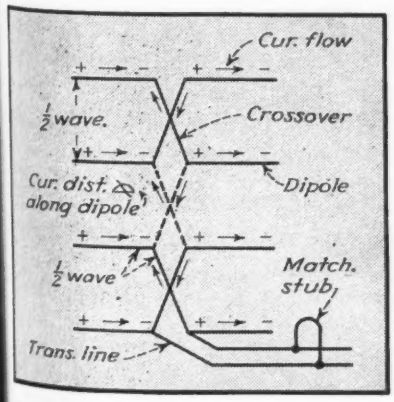


FIG. 8—Basic directive array scheme, showing eight of the sixteen transmitting dipole elements. The associated reflectors are omitted in this drawing

There is, therefore, a tendency of the current in this circuit to oscillate and over-shoot in the negative direction. This causes the transmitter to be cut-off sharply at the conclusion of the pulse. Any further oscillation in the modulator circuit is suppressed by the blocking diodes.

Modulator wave forms are shown in Fig. 6. It is to be noted that the pulse lasts only about 2.5 percent of the total time, so that only a small portion of the charge stored in capacitor C is withdrawn during each pulse. The diodes permit this charge to be replaced, at a slow rate, between pulses. But the diodes, being one-way conductors, have no effect during the pulse discharge.

The Transmitter Proper

The function of the transmitter is to develop r-f pulses of 75 kw peak power. The average power is not nearly so great, however, since the transmitter is turned on only 2.5 percent of the time (4098 pulses, each about 6 microseconds long, per second). The essential problem of the transmitter design, then, is providing sufficient emission in the transmitter tubes to meet the momentary high power requirements. The required peak emission, as indicated from the discussion of the modulator circuit, is of the order of 10 amperes. No suitable tube was available with such emission, so it was necessary to employ a large number of tubes. The tubes are type 100TS.

It was not feasible to connect the transmitting tubes in parallel or in push-pull-parallel because the addition of the tube capacitances would prohibit operation at the high frequency desired. To avoid this difficulty, the ring circuit was adopted. Essentially, this is a multiple push-pull tuned-grid tuned-plate arrangement. In this circuit, an elementary form of which is shown in Fig. 7, the tubes are separated by tuned circuits and arranged in a closed ring. As shown, grids of adjacent tubes assume opposite polarity, and to sustain oscillations the plate of each tube has the opposite polarity from its grid. When an even number of tubes is employed in the ring, the necessary alternation of grid and plate polarities between adjacent tubes is maintained throughout the ring. Since the tube capacitances are essentially in series, any required number of tubes may be employed. Sixteen tubes are required to provide the necessary emission.

The tuned circuits are segments of parallel transmission lines, approximately half-wavelength long, with adjustable shorting bars. The r-f current in all the shorting bars, at any instant of time, is in the same direction, so the shorting bars form a virtual closed circuit from which energy may be picked up by a pick-up coil. A single-turn pick-up coil is used to connect the transmitter to the output transmission line.

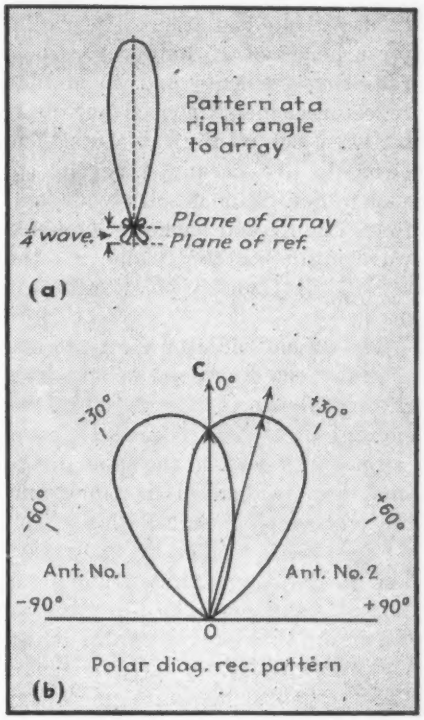


FIG. 9—(a) Directive pattern of receiving array with reflectors spaced ¼-wavelength apart. (b) Double receiving antenna pattern, obtained by lobe switching described in the text

The filament power for the transmitter tubes is conducted through quarter-wave concentric transmission lines, shorted at the input end. These segments prevent absorption of r-f power by the filament circuit.

The modulator is connected to the transmitter through a high-voltage slip ring which permits the pedestal to turn when following targets without breaking the connection. The transmitter plate circuits are joined at points below the shorting bars and connected to ground. The

modulator output, in the form of a high-voltage negative pulse, is applied to the transmitter filaments. The transmitter grids are joined at points beyond the shorting bars and returned to the filaments through a resistance.

Transmission Line and Radiator

From the pick-up coil, the transmitter output is conducted over an open-wire transmission line to the transmitting radiator. The radiator consists of 16 half-wave dipole radiating elements and 16 similar reflector elements spaced one-quarter wave behind the radiators. The elements are arranged parallel to each other, four dipoles wide and four high, and spaced one-half wavelength in the plane of the array. Horizontal polarization is used.

The dipole radiator elements are interconnected cross-wise at their ends as shown in Fig. 8. Thus the current in each half-wave segment in the array flows in the same direction, at any instant of time, and there is complete cancellation of the r-f field in the plane of the array. The field is a maximum along an axis at right angles to the plane of the array, thus providing the necessary directivity of transmission. The transmitting antenna beam width is about 10 degrees wide between the 3-db points, that is, the field radiated five degrees off the axis is 3 db less than the field along the axis. The gain of this radiator, relative to an isotropic (point-source) radiator, is about 400 times. Thus the effective power radiated to the target is about 400 x 75 kw = 30,000 kw. A matching stub is used on the transmission line to match the impedance at the ends of the dipoles.

Receiving Arrays and Lobe Switching

The receiving arrays are very similar to the transmitting radiator, differing only in shape and in the provision of lobe switching. The azimuth array is six dipoles wide and four dipoles high, with a similar number of reflectors. The radiation pattern formed by this arrangement is a fan-shaped figure with its long dimension in the vertical plane, which permits discrimination in the azimuth (left-right) coordinate. The elevation array is arranged two dipoles wide and six dipoles high with corresponding reflectors. The radiation fan in this case has its long dimension in the horizontal direction, an arrangement suitable for discriminating in the elevation (up-down) coordinate.

Both receiving arrays are arranged for lobe switching to refine the accuracy of the angular indications. The technique is as follows: The directivity pattern of an array is a lobe-shaped figure like that shown in Fig. 9(a). Suppose, first, that two arrays are used side by side at a slight angle to one another. Then two overlapping lobes are provided. The signals received from the two arrays are of equal amplitude when the signal arrives from a direction midway between the two lobes as along line OC in Fig. 9(b). If the signal arrives from the left the signal from the left-hand lobe predominates, whereas a signal from the right causes maximum amplitude in the right-hand lobe. The sharp slope of the lobe patterns at their intersection makes the direction of equal amplitude correspondingly precise.

The technique of lobe-switching provides a double-lobe pattern from a single array. The array is divided into two halves (left and right halves in the azimuth array) which are connected not by cross-wires as in the transmitting arrangement but by phasing stubs, that is, adjustable segments of transmission line somewhat less than a half wavelength long. Two terminations are taken from the array, one at the left end, the other at the right end as shown in Fig. 10. The directivity of such an array, with phasing stubs inserted, is found to be slightly different, depending on which termination is used.

To illustrate this effect, consider

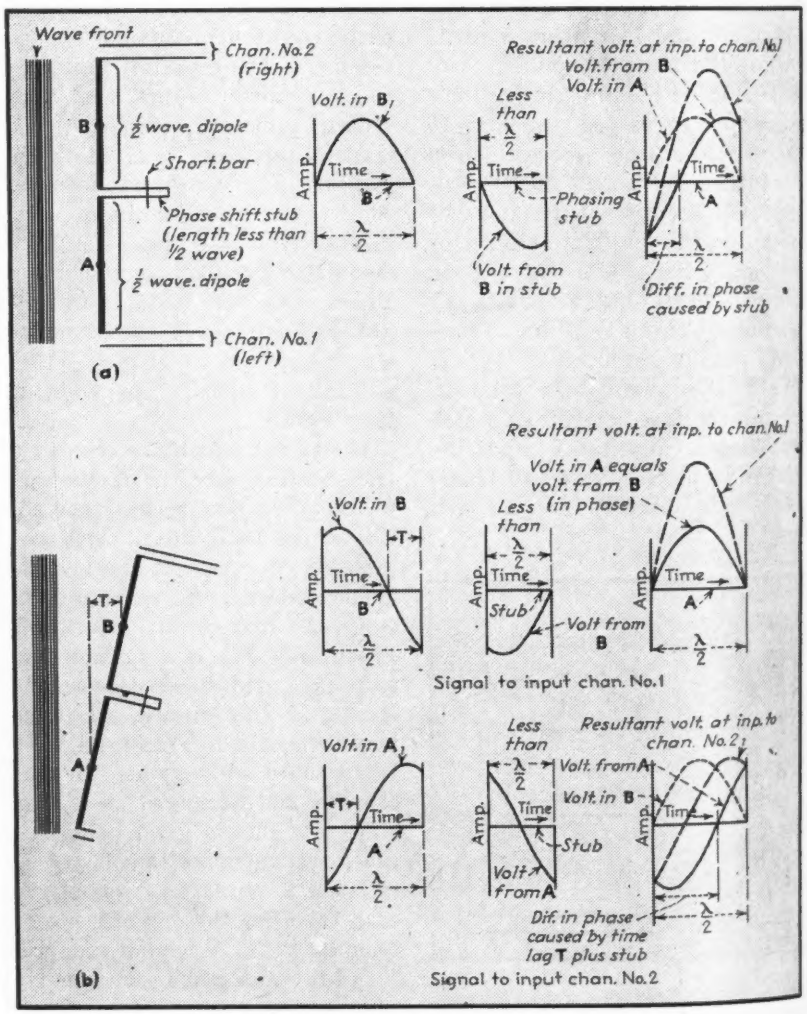


FIG. 10—SCR-268 radar receiving antenna lobe-switching results showing (a) voltage when the plane of the array is parallel to the wave front and (b) voltage when the plane of the array is at an angle to the wave front

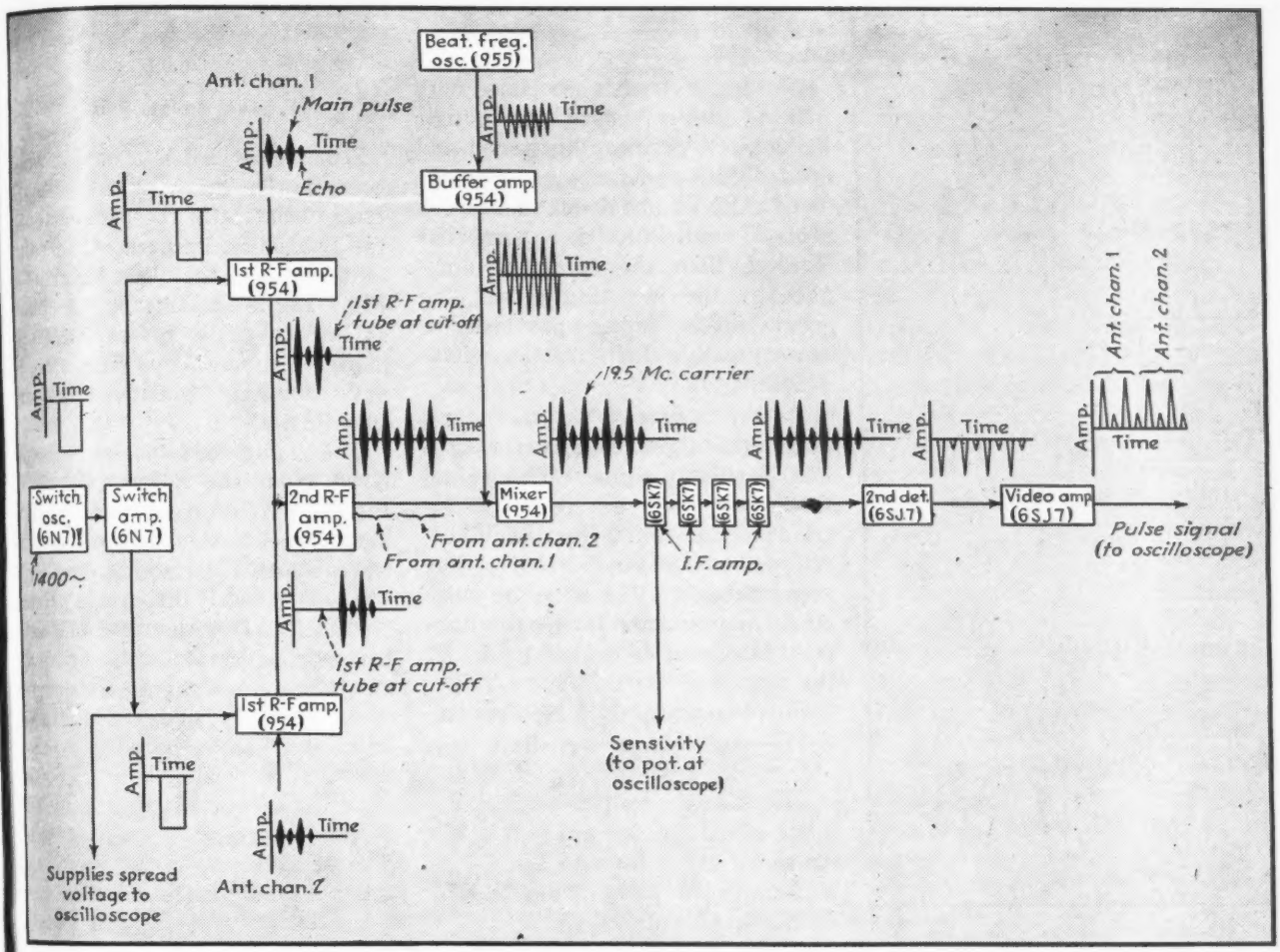


FIG. 11—Functional block diagram of one of the two receivers

a signal wave front arriving parallel to the array. The wavefront induces voltage in the two halves of the array at the same instant. Consider the array from the back and assume that the left-hand termination is in use. The signal induced in the left half of the array arrives at once at the termination, but the signal from the right half of the array arrives at the left-hand termination only after a delay caused by its passage through the phasing stub. Hence the net voltage arriving at the left-hand termination is a vector sum, and this vector sum is the same as though the wave had arrived from an angle to the left and as if no phasing stubs were present. The phasing stubs thus cause the antenna pattern to shift to the left when the left-hand termination is in use.

By the same process, the stubs cause the directivity of the array to shift to the right when the right hand termination is in use. By shifting alternately from left-hand to right-hand termination, the effect of two lobes is produced. Accurate direction finding is obtained when the signals from the two terminations have the same amplitude. In the elevation array, the array is divided into top and bottom halves and the same effect is produced in the elevation coordinate.

In practice, the phasing stubs are adjusted when receiving a wavefront of known orientation until the peaks of the lobes are spaced approximately 10 degrees and a symmetrical variation in signal is obtained on either side of the center direction. Thereafter this adjustment is preserved until the radar moves to a new location. A signal generator ("tweeter") produces the required wavefront and a technique has been developed to avoid the effects of external reflections. As in the case of the transmitting array, matching stubs are employed on the transmission lines to match the receiving array impedance to the line.

One possible source of trouble in the operation of the radar is the existence of side lobes, that is, minor directivity patterns offset from the main pattern by some 25 degrees. Proper adjustment of the array will keep the sensitivity of the array in these side directions about 30 db below that of the main lobe, but the effect cannot be eliminated entirely. Thus a nearby target centered in a side lobe may produce a stronger signal than a distant target centered in the main lobe. Moreover, at the intersection between the left-hand main lobe and a right-hand minor lobe signals of equal amplitude will appear. The array will then be pointed, not at the target, but some 25 degrees away from the target. The true lobe intersection can, however, always be determined by noting the symmetry of the signal variation as the array is moved either side of the equal-amplitude direction. The false balance is not symmetrical.

The Receiver

Two identical receivers are employed in the SCR-268, connected to the elevation and azimuth arrays. A block diagram of the receiver is

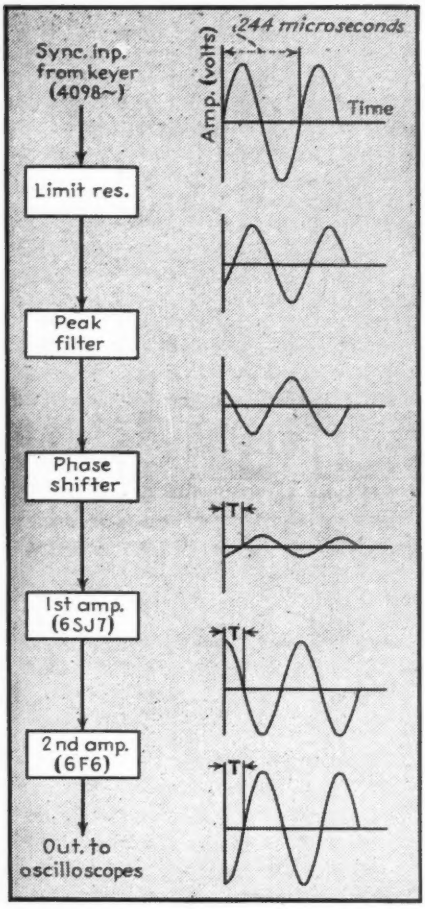


FIG. 12—Diagram showing how the SCR-268 radar range unit functions

shown in Fig. 11. Two antenna inputs are provided, for each of the two terminations of the array. These are connected to separate r-f amplifiers (type 954 acorn pentodes) which are switched alternately on and off to provide reception alternately on the respective lobes of the array.

The switching is accomplished by applying a rectangular wave of voltage to the grids of the r-f stages, the wave being obtained from a multivibrator (switch oscillator, 6N7 double triode) and a subsequent amplifier (6N7). The multivibrator produces a rectangular wave at a frequency of approximately 1400 cps. Approximately three pulses and echoes are passed through one r-f stage while the other is blocked. Thereafter, the first r-f amplifier is blocked and the second passes three pulses. In this manner reception is switched rapidly from one lobe to the other.

The two r-f stages are joined together at their plates. Hence at this point the successive lobe signals are interspersed in time sequence. Thereafter, the joint signal is amplified by a second r-f stage (954).

The tuned circuits associated with the r-f stages consist of a single inductance, permeability tuned and loaded with resistance to present a bandwidth of about one megacycle. This bandwidth is somewhat greater than the spectrum occupied by the incoming pulses, the extra space being provided to cover possible shifts in transmitter frequency.

At the output of the second r-f stage, the signal is mixed with a local oscillator signal. This signal is derived from a type-955 acorn triode oscillator in a Hartley circuit, followed by a 954 buffer stage. The mixer tube is a 954, with the pulse signal and local oscillator output applied jointly to its control grid. At the output of the mixer the difference frequency of 19.5 Mc appears.

The 19.5 Mc intermediate frequency is amplified in four i-f stages (6SK7), coupled with single tuned circuits which are permeability tuned and loaded to achieve 1-Mc bandwidth. The voltage gain of each stage is about 12, or $12^4 = 21{,}000$ overall for the four stages.

The second detector is a triode (6SJ7) operated at cut-off bias. The detector feeds a video amplifier (6SJ7) having a gain of about 2.5. The output (taken from the plate of the video amplifier) is about 10 volts peak-to-peak maximum into a 500-ohm output circuit. Any signal higher than this saturates the video amplifier.

The sensitivity of the receiver is such that, at maximum gain, the noise developed at the receiver input will saturate the video amplifier. Sensitivity is controlled remotely, from a control associated with the cathode-ray indicator. The sensitivity control voltage is applied to the cathode of the first i-f stage.

In addition to the video output, the receiver provides a "spread voltage" for separating the indications of the two lobes on the cathode-ray indicator screen. The spread voltage is derived from the output of the switching amplifier. To assure that the gain in the two lobe channels is equal, a balance control is provided in one of the first r-f stages. This balance control is set during the calibration procedure, using a standard signal generator.

The Range Unit

The range unit is a device which controls the timing of the indicator traces relative to the production of the transmitted pulses. The range unit shown in the block diagram of Fig. 12 is essentially a phase shifter, capable of shifting the phase of the 4098-cps sine wave by any amount, continuously and smoothly.

The input 4098-cps wave is derived from the keyer (shown in Fig. 4). After passage through a limiting resistor, and through a filter to remove harmonics, the sine-wave is passed through a Helmholtz coil. This device consists of two sets of stator coils, arranged at right angles. The current fed one set of coils is advanced 90 electrical degrees by passage through a capacitor-resistor network. The result is a rotating magnetic field at the center of the coil system. This field induces a sine-wave voltage in a small pickup coil at the center of the system. The phase of the induced voltage is fixed so long as the pick-up coil is stationary. When the coil is rotated, the phase shifts in direct proportion to the angular motion of the coil. The induced voltage is amplified in two stages and the output is fed to the indicators as subsequently described.

The Indicator Units

Three identical units are used as indicators by the range, elevation and azimuth receiving antenna array operators. These indicators are very similar in appearance and function to a conventional cathode-ray oscilloscope. Besides the basic power supply, the indicator units derive three voltages from the other units of the radar: (1) the pulse signal from the video amplifier of the associated receiver, (2) the spread voltage from the switch amplifier of the receiver, and (3) the phase-shifted 4098-cps sinewave from the range unit.

A block diagram of one indicator, showing its waveforms, is given in Fig. 13. The basic synchronizing input comes from the range unit. This sinewave voltage is first amplified in an over-driven sync ampli-

er (6AC7). The negative grid voltage cutoff and positive grid current saturation convert the sinewave input into a more nearly rectangular wave which is fed to a pulse generator (6L6), also overdriven. In the plate of this high-current tube is an inductance. The sudden current changes at the sides of the rectangular wave, passing through this inductance, induce high peaks of voltage which are used to control the following sweep-voltage generator after passing through a peak filter.

The sweep generator consists of a capacitor, charged through the 6L6 sweep generator tube. The approximately constant current characteristic of the 6L6 results in a closely linear increase in voltage across the sweep capacitor until the sudden positive peak arrives from the preceding peak filter. Then the capacitor is suddenly discharged by the heavy reverse current passed by the sweep generator tube. The result is that the voltage across the sweep capacitor has the saw-tooth form required for deflecting the electrostatic cathode-ray tube.

Before application to the c-r tube, the sweep voltage is amplified (6SJ7) and mixed with the spread voltage. The spread voltage, which we recall is synchronous with the lobe-switching, is amplified (6SJ7) and causes the saw-tooth sweep wave to be displaced bodily upward and downward, as shown in the figure. Thus the sweep associated with the one lobe-channel is displaced horizontally on the c-r tube with respect to the sweep associated with the other lobe-channel. This causes the image to appear "split" as shown at the bottom right in the diagram.

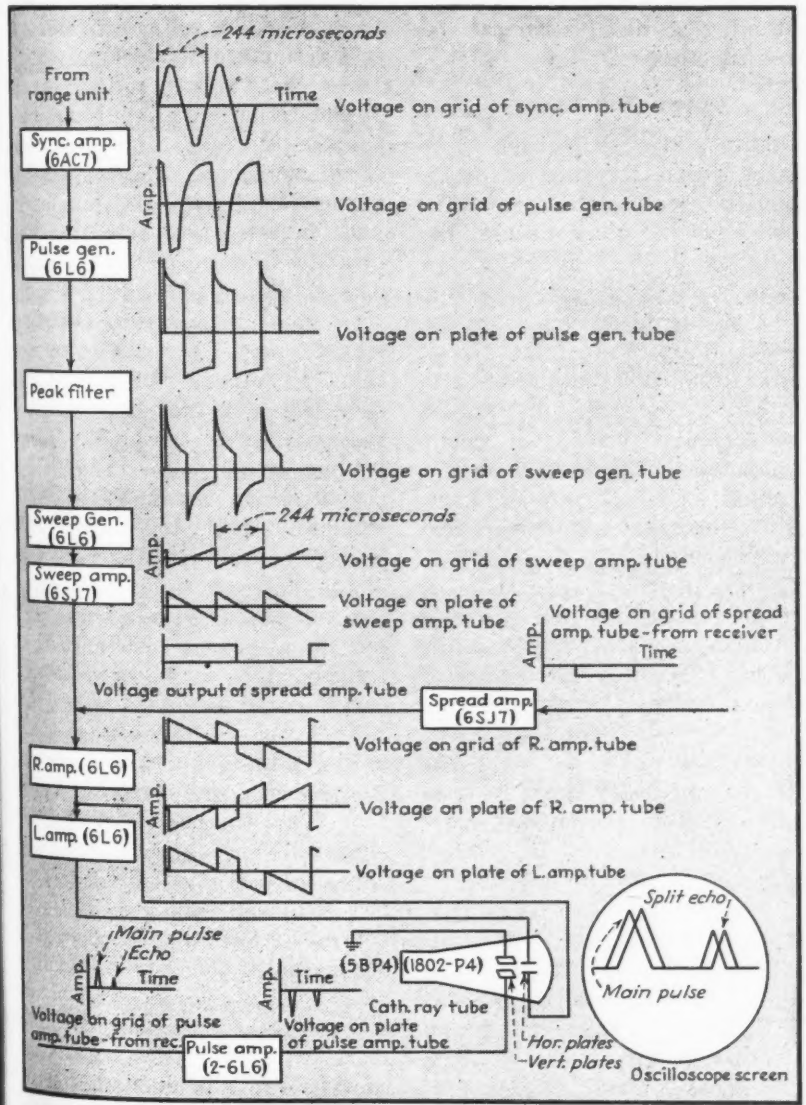


FIG. 13—Functional block diagram of one of the three oscilloscope indicating units

The displaced sawtooth wave is applied to two amplifiers (6L6's) which produce symmetrical waves of opposite polarity for application to the horizontal deflection plates of the c-r tube. The symmetry is essential to produce a linear sweep.

The receiver output is amplified in a pulse amplifier (2-6L6's) and then applied to the vertical deflection plates. The resulting screen pattern is a series of pulses in pairs. The first pair is a split image of the transmitted pulse, which is transmitted directly from the transmitting array to the receiving array. The receiver is considerably overloaded at this instant, and the pulse saturates the amplifiers and hence is flattened at the top. No special device is provided to protect the receiver during the transmitted pulse. The next pair of pulses to the right is a split image of the pulse echo from a target.

In operation, the azimuth and elevation operators adjust the spread voltage and the amplitude of the pulses until the split image is displayed conveniently for comparison of the amplitudes of the two components of the split image. Thereupon the angular orientation of the corresponding array is adjusted until both components are of equal height. The array is then pointed directly at the target.

Range Indicator

The range indicator does not make use of the spread voltage so only a single image appears for each echo. The range operator adjusts the phase shift of the range unit until the target echo appears under a cross-hair on the associated scope screen. The range to the target is then read off the phase-shift dial, which is calibrated in thousands of yards.

The SCR-268 employs 110 vacuum tubes, which are divided among the several units as follows: high voltage rectifier 4, keyer 11, range unit 3, modulator 10, transmitter 16, two receivers 15 each, three indicators 12 each. Despite this fact, and the evident complexity of the circuits, the 268 has proved to have outstanding serviceability in the field. —D.G.F.

References

(1) Fink, D. G., The Radar Equation, *Electronics*, p. 92, April 1945.

TRANSIENT PEAK V

By C. RYERSON and M. ARONSON

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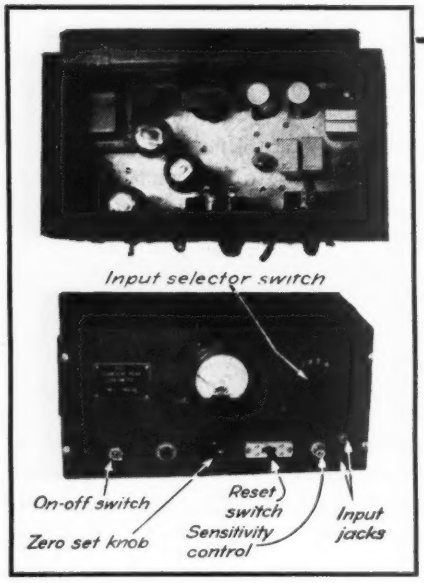

FIG. 1—Top and panel views of the transient peak voltmeter

THE INCREASED USE of single transient voltage pulses in special electronic applications has created the need for a device which can measure such pulses quickly and accurately.

Since neither d-c nor continuous-wave a-c voltmeters respond fast enough to short-period voltage changes, attempts have been made to perform this function by employing oscillographic apparatus or special observational techniques. Although adequate in some cases, such methods are at best time-consuming and involve the use of specialized equipment which is hard to obtain. Moreover, experience indicates that to employ these methods properly requires considerable practice and that the operating techniques are essentially difficult to teach the average technical worker.

The authors of this paper have designed a compact transient peak voltmeter which will measure fast voltage surges as easily as a standard voltmeter measures voltage of longer duration. It contains standard electronic components and an easily read panel-type meter. No particular operational technique is required.

The transient peak voltmeter to be described uses the fast transient signal of the circuit under test to charge a low-leakage capacitor through a diode in the voltmeter circuit. The high inverse impedance of this diode allows the capacitor to remain charged for a considerably longer period than that of the signal. By making the capacitor's discharge time sufficiently long, the initial charge can be measured by means of a high input impedance balanced bridge containing a d-c instrument between the arms.

General Description

Figure 1 is a photograph showing the simple construction of the transient peak voltmeter. The housing is a black-crackle box measuring 7 by 7 by 14 inches. Power is obtained from a built-in power supply operating from the 115-volt line. The entire circuit uses but four tubes and a 0-to-200-microampere indicating instrument. The controls include a range-adjustment switch, a reset switch, an on-off switch, a zero-set knob, and a screwdriver-adjustment sensitivity control.

The circuit will measure the peak value of the input signal and hold the reading for several seconds, or until reset by the manipulation of the reset switch. There are four input voltage ranges of 1, 5, 10, and 50 volts full scale, to cover the most generally used range of voltages. Higher or intermediate ranges can be added if desired. Lower ranges could be provided by the addition of suitable amplifiers. The input circuit has a constant input impedance of 20 megohms and contains a blocking capacitor which prevents direct current in the measured circuit from affecting a measurement.

The frequency response characteristics of such a voltmeter can best be considered as the response to single transients with various times to the peak. Assuming the pulses to be the equivalent of one-half cycle of sine wave, the response is flat within 2 db from five milliseconds to one-half second and time to the peak.

Circuit Theory

Figure 2 is a block diagram illustrating the essential circuit functions. The voltage divider (A) is a resistance network which provides the various voltage ranges to match the signal input and maintains a constant input impedance of 20 megohms. The amplifier-inverter (B) provides a gain of ten and inverts the signal voltage polarity from positive to negative. The amplified and inverted signal then goes through the impedance transformer (C) which is no more than a cathode follower circuit used to match the plate circuit of the amplifier to the low-impedance hold-on circuit (D). The hold-on circuit is an arrangement which employs a diode to charge a low-leakage capacitor to the peak value of the incoming signal. The charging impedance of this circuit is low but the discharge resistance is extremely high, in the order of several hundred megohms.

The value of the voltage which is fed into the hold-on circuit is measured by the balanced bridge (E). This voltmeter circuit is designed to have high input resistance, so that the signal will not be dissipated by the measuring device. At the conclusion of a measurement the hold-on circuit is reset and made ready for a new signal by the manipulation of the reset switch (F). This action discharges the hold-on capacitor.

Figure 3 shows a simplified version of the circuit schematic

K VOLTMETER

The amplitude of a single short pulse is determined by amplifying the transient voltage, then charging a capacitor through a hold-on circuit which permits the charge to be maintained long enough for measurement by means of a balanced-bridge d-c voltmeter equipped with a 0 to 200-microampere indicating instrument

in which the blocks of Fig. 2 have been replaced by appropriate circuit components, the order remaining the same. The functions which have just been outlined can better be understood by a comparison of these two figures.

A few additional features will be noted in Fig. 3 and 4. The potentiometer control R_1 adjusts the sensitivity of the voltmeter and is used during calibration. The control R_2 is the zero-set adjustment which provides balance between the tubes of the voltmeter bridge.

The voltmeter bridge is a double cathode follower arrangement, with the input signal applied to the grid of tube VT_2, the balance potential applied to the grid of VT_3, and the indicating instrument connected between the cathodes of these two tubes.

Figure 4 is a complete schematic diagram of the transient peak voltmeter, showing all electrical details. The compensation network in the grid circuit of the cathode follower tube VT_2, consisting of resistances R_3, R_4 and C_1, improves the frequency response of the preceding amplifier tube VT_2 by increasing the input impedance of the cathode follower circuit. The bias cell in the input to VT_2 is necessary in order to cancel the diode potential which otherwise would cause a spurious zero reading. The presence of this cell requires that the reset switch be connected to discharge the capacitor without shunting the bias cell.

The voltage which is applied across the balance or zero set resistor R_2 is in practice obtained from a small C-battery. This arrangement is more stable than the method shown in Fig. 3 except when a B-supply which is regulated against output voltage fluctuations is used.

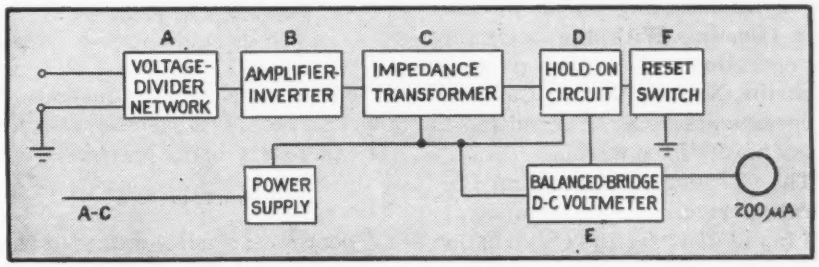

FIG. 2—Block diagram showing essential circuit functions

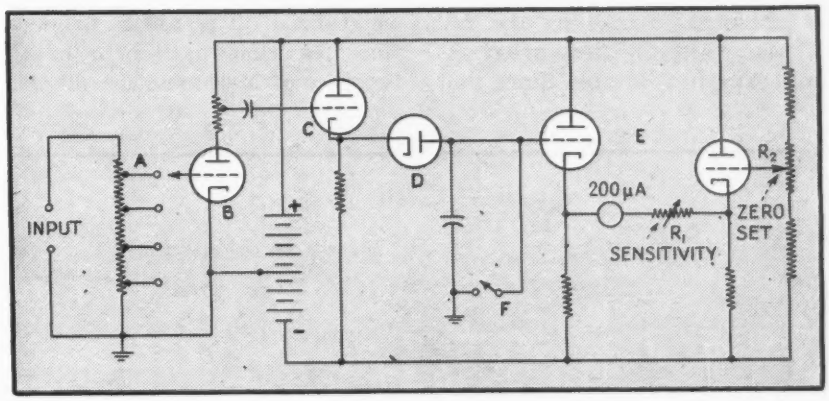

FIG. 3—Simplified circuit diagram. Identifying letters correspond to those in Fig. 2

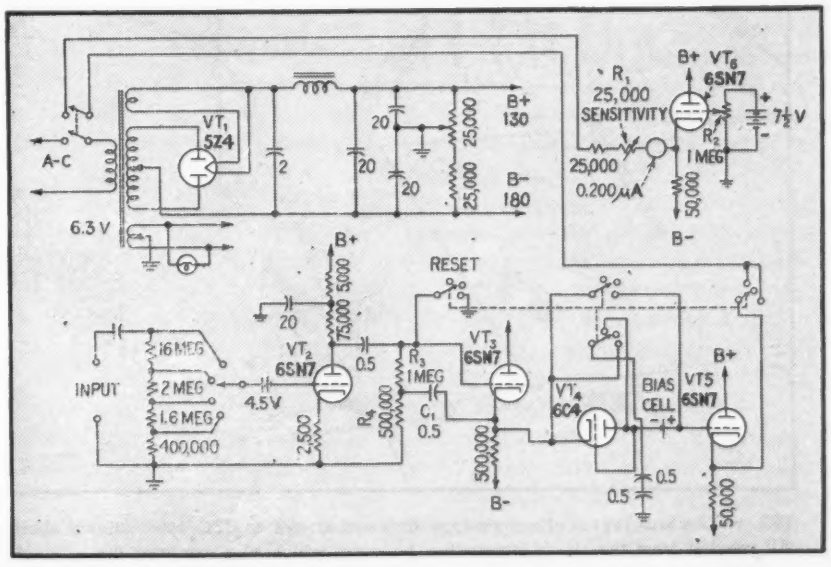

FIG. 4—Complete transient peak voltmeter circuit

Canada's INTERNATIONAL

By H. M. SMITH
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CANADA has now joined those nations which have undertaken broadcasting on an international basis. With the beginning of operations of a new plant at Sackville, New Brunswick, Canadian programs are being transmitted to many parts of the world.

The Canadian Broadcasting Corporation received authorization in the fall of 1942 for the construction and operation of a major short-wave plant. The building was completed, two 50-kw transmitters and speech input equipment installed, and antennas erected by the fall of 1944, when the first programs were beamed to Europe. Since that time there has been an increase in the number of transmissions, and still more are being added.

Choice of Site

Theoretical studies indicated that the plant would have to be located in the eastern part of Canada if minimum trouble from the earth's magnetic field distribution were to be realized. The north magnetic pole lies somewhat north of the Province of Manitoba, considerably south of the geographic pole. This results in a region of relatively high flux density, usually known as the disturbed zone, extending radially from the magnetic pole for several hundred miles. Both theory and experience indicated the wisdom of locating outside of this zone.

Previous experimental investigations of transatlantic reception had been carried out by the Engineering Division of the CBC. BBC programs on various frequencies were recorded simultaneously at Ottawa and at a location south of Halifax on the Atlantic coast. Simultaneous records of field intensity were also made at these points. An im-

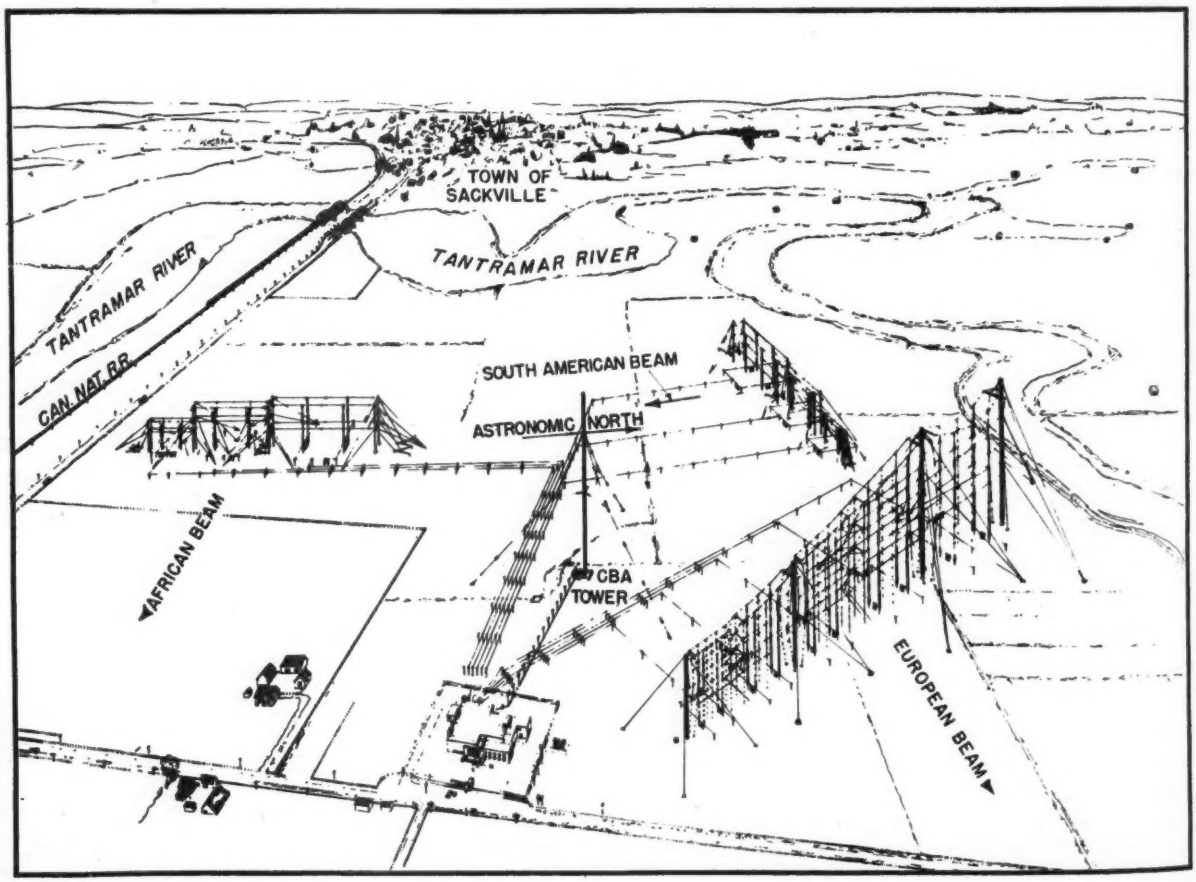


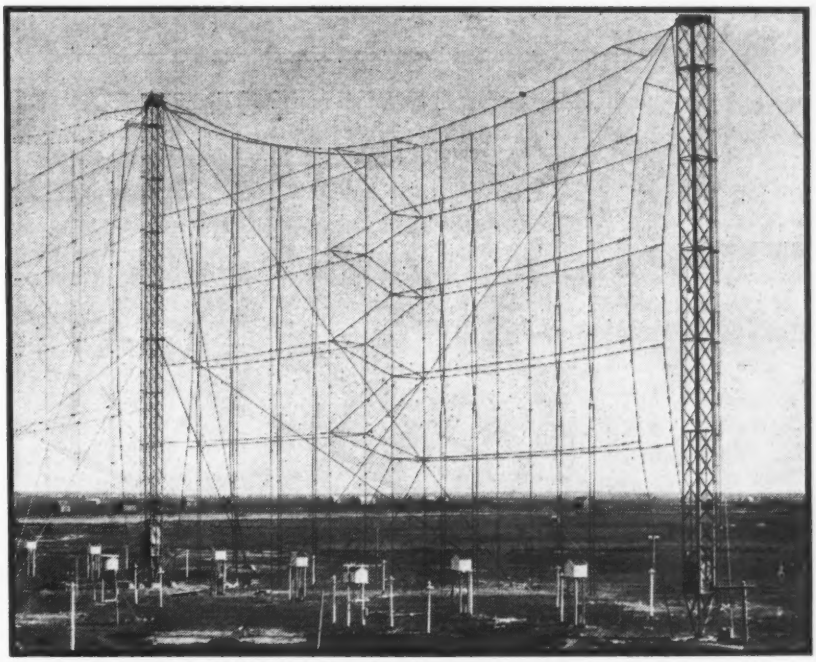
FIG. 1—General layout of curtain-type antenna arrays at CBC international short-wave plant at Sackville, New Brunswick. All are fed from the single transmitter building, which also contains the original 50-kw broadcast-band transmitter feeding the guyed vertical radiator of station CBA. All three beams can be reversed, as well as electronically slewed a few degrees off their normal paths. The European beam system has much higher gain than the others

SHORT-WAVE PLANT

Description of facilities newly installed at Sackville, New Brunswick, for operation in the 6, 9, 11, 15 and 17-mc bands. High-gain curtain-type antenna arrays are beamed in three directions, with slewing systems for covering areas wider than the usual beam width

provement of several db in signal strength was obtained, and the amount and nature of fading was very strongly in favor of the eastern location. While other factors entered into the selection of the site this work could not be ignored.

The CBC had previously located one of its 50-kw broadcast stations, CBA, at Sackville, New Brunswick, a town near the border of Nova Scotia and approximately 90 airline miles northwest of Halifax. In this part of New Brunswick there are extensive marsh areas—large bodies of land reclaimed for agriculture from the tidal waters of the Bay of Fundy by dyking. This low-lying, rich soil is continually moist, an asset for ground systems. The town is well served by transportation, both rail and highway. Further advantages included existing staff and program line facilities. The decision was therefore taken to locate at Sackville, and previous property holdings were increased to approximately 200 acres of land.



Details of typical curtain-type arrays. The 17-mc array is to the right of the zig-zag suspension cables, and the 15-mc array is to the left. The tiny houses near the ground contain switching relays

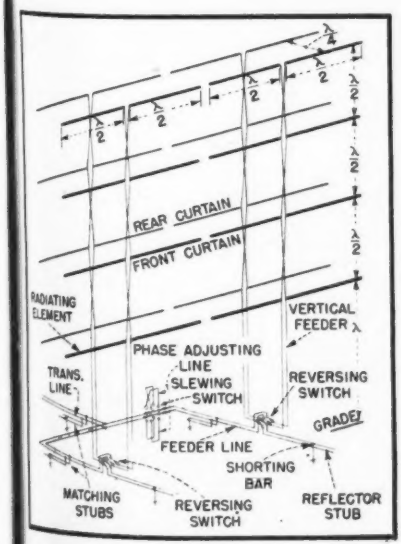


FIG. 2—Curtain-type array for a single frequency, with reversing and slewing switches shown schematically

Selection of Antennas

The plans developed called for transmission to Europe, Australia, New Zealand, South Africa and South and Central America. On laying out the beams for these areas, it became apparent that if provisions for beam reversal were included, the major land areas of the earth could be covered fairly well.

Three antenna systems were provided, being designated as European, South American and Australian. As the names imply, they were laid out for beam width and direction to these areas. Upon reversal, these antennas provided coverage to Central America and New Zealand, Eastern Asia, and South Africa, respectively. Each antenna system consists of several directional arrays for operation in the 6, 9, 11, 15 and 17-megacycle bands. Present plans call for the addition of 21-megacycle antennas in the future. The general layout of the antenna systems is shown in Fig. 1.

Considerations of site, results desired and economics led to the decision to use curtain-type antennas, rather than the simpler rhombic type having somewhat lower efficiency. It was felt, and experience

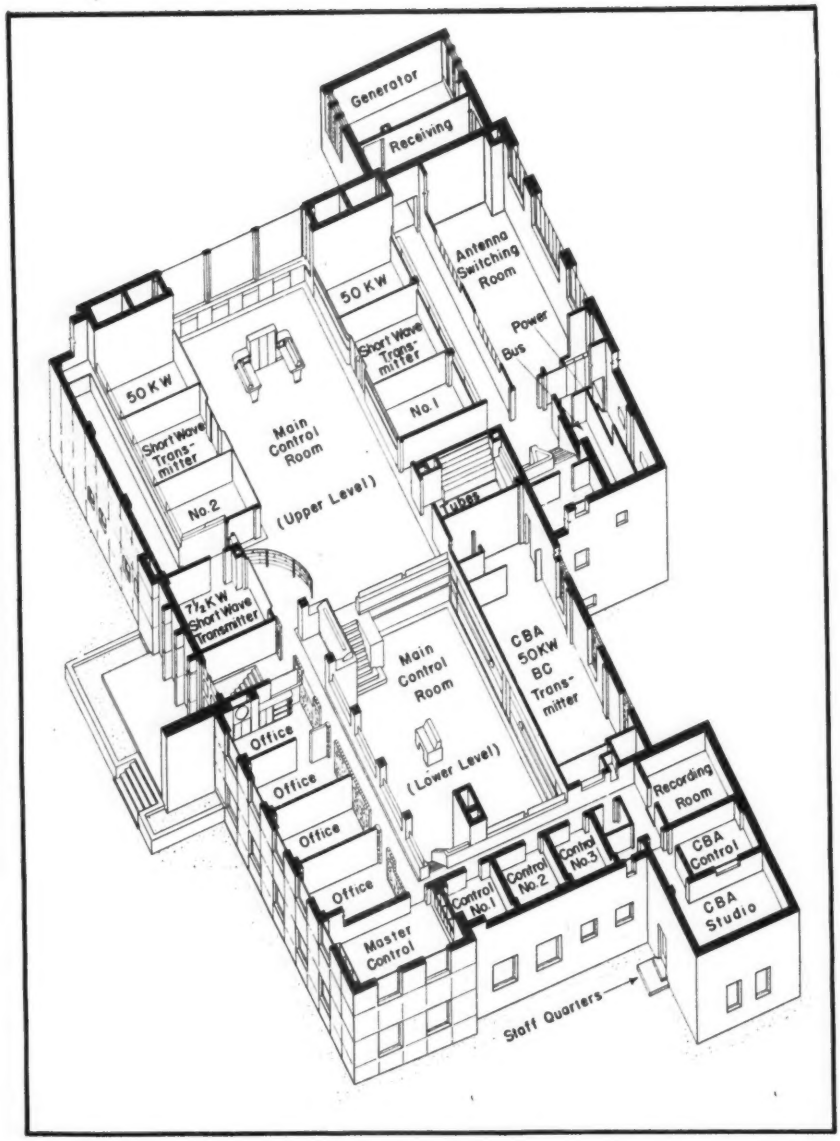


FIG. 3—Isometric view of main floor of CBC short-wave building at Sackville

confirmed, that the lower vertical angle of radiation realizable with the curtain type would materially improve reception.

Special considerations, mainly associated with the war, made it desirable to increase the field intensity directed toward Europe, and the European antenna system was therefore designed for somewhat higher gain than the others.

The antenna systems, particularly the European, are rather unique in design, and have substantial gain. Each antenna of the European system consists of a driven curtain and a nondriven reflecting curtain, identical in form and located behind the driven elements as in Fig. 2. Each curtain except the 6-mc consists of eight horizontal elements, arranged in two side-by-side vertical stacks of four; the length of each element is slightly under one wavelength. All elements of the driven curtain are driven in the same phase at their centers by vertical transmission lines. The lines from the two side-by-side stacks come together a short distance above the ground level and tie onto the main feeder line from the station. Remotely controlled reversing switches are located at the base of each of the vertical lines and are so arranged that they can connect driving power to either the front or back curtain, simultaneously connecting a stub to the undriven curtain. These switches are energized from an antenna switching panel, located in the transmitter building.

Another remotely controlled switch is located in the feeder to one of the vertical stacks of each antenna. This is arranged to feed in any one of three ways at the discretion of the controlling operator. Normally the feeder provides a circuit directly through the switch; the feed is then symmetrical with that to the other stack. In the second position the switch introduces a predetermined amount of additional feeder, thus inserting a phase delay in its stack in comparison with its companion stack. This serves to swing or slew the beam a few degrees from its normal path and provide better signal strength in desired areas which are not covered fully with the beam in its normal position. Similarly, with the switch in its third position, a phase advance is introduced in one stack, slewing the beam in the opposite direction. This arrangement provides a degree of flexibility which is useful in covering areas wider than the usual beam width.

The European system has five antennas. The 17 and 15-mc antennas are slung on messenger cables between the first two towers, the 11 and 9-mc units are between the next two, and the 6-mc unit uses the last two towers. These antennas give measured gains of slightly over 20 db. The 6-mc antenna is generally similar to those of higher frequency except that it has 6 driven elements instead of 8 and a similar arrangement in the reflecting curtain. Measurements made in England confirm the performance, in field intensity received and a reduction in fading in comparison with other antennas.

Building Design

Early in the planning the decision had to be made whether or not to house the short-wave facilities in a building separate from the CBA broadcast plant or combine them. While the latter course was much more difficult, entailing the removal of large sections of the existing building while keeping the broadcast plant in operation, the resulting overall economies and flexibility in operations led to its adoption. The old building was largely torn down above ground; temporary housing was erected over the equipment in service, and a new and larger structure built.

Fig. 3 shows the general lay-

out of the main floor. The transmitter room is 120 feet long. It houses the two short-wave transmitters, with the CBA broadcast transmitter in a well a half story below the main floor. Heavy plate glass parapets surround the broadcast transmitter well. The walls above the transmitters and the full ceiling area of the main transmitter room are acoustically treated for high absorption.

The north section of the building houses a broadcast and two short-wave program control booths, an emergency studio, recording room and master control, all acoustically treated. This section is shielded by two concentric copper screens built into the walls and carried through the double doors leading to each of these rooms. Along the front of the building are located offices for the staff.

At the rear of the building are tube storage rooms, power distribution facilities, power metering panel, antenna switching room and stand-by generator room. A ramp at the rear of the building leads to an interior freight entrance. The basement contains additional office space, emergency staff quarters, shop, shielded laboratory. transmitter cooling and air conditioning equipment, furnace and fuel storage, together with various store-rooms for spare equipment and supplies.

The staff quarters provide a modern kitchen, dining room, lounge, showers, and three bedrooms each containing two built-in single beds. Rather severe winter storms have made it necessary to provide facilities of this type, for it is not unusual for the staff to find itself snowed in for a day or two. These quarters also have decided virtues after late engineering sessions on the equipment.

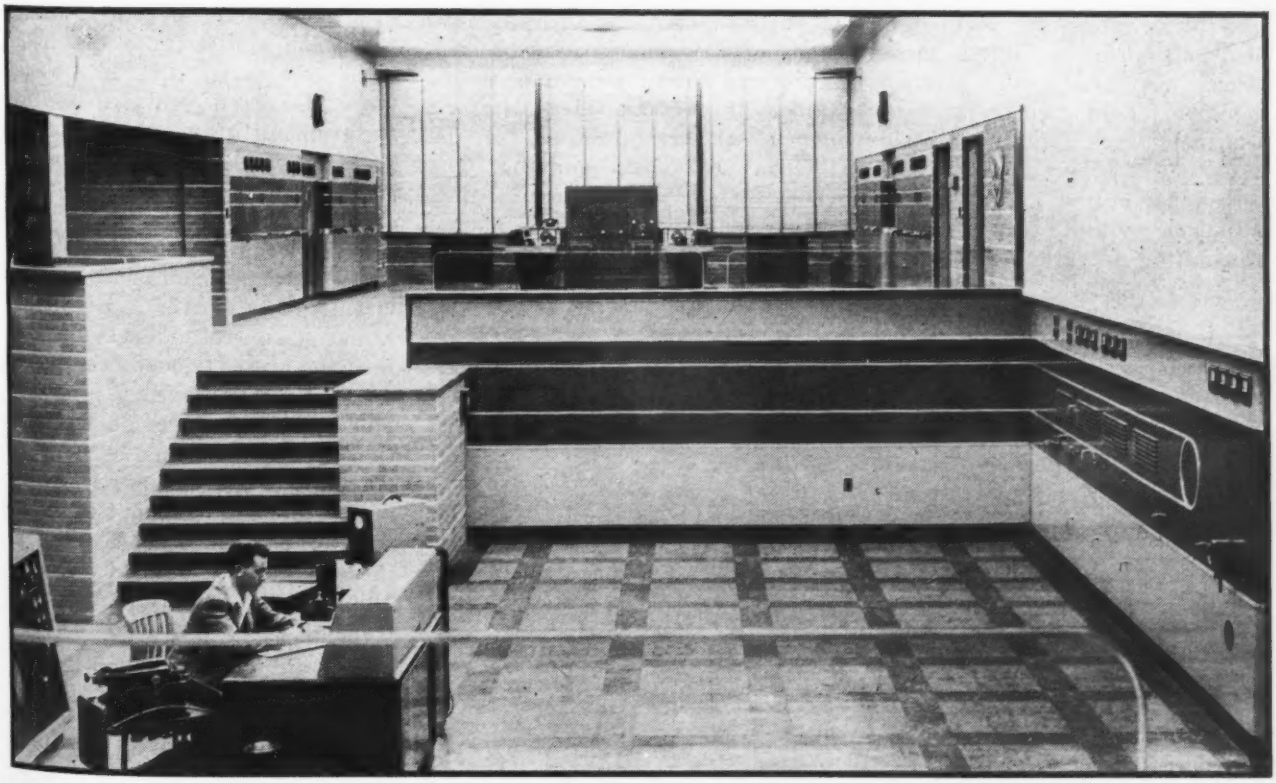
In winter some of the heat carried by the transmitter cooling equipment is injected into the air conditioning system. Two large electric stills are housed under the roof space. These discharge into a large distilled water storage tank in the basement. The water may be piped to any of the working tanks associated with the cooling systems of any of the transmitters.

Power Distribution

Three-phase 60-cycle power is obtained from a commercial steam plant about 15 miles distant from the station. It is delivered at 23 kv and brought down to 2300 volts at a substation on the property. The total load of the station is about 750 kva.

The incoming power feeds a 2300-volt bus through an oil circuit breaker. From this bus individual branch feeders lead to each of the three transmitters, the three-phase 220-volt domestic service bank, the single-phase domestic bank, and the antenna lights. A metering panel contains watthour meters for total station load, total transmitter load, short-wave transmitter No. 1, short-wave transmitter No. 2, broadcast transmitter, three-phase domestic load, single-phase domestic load, and antenna lighting load.

Three line voltmeters are permanently connected across the main 2300-volt bus and a recording voltmeter can be switched to any phase. Three ammeters, a graphic wattmeter and a recording wattmeter can be switched into any of the major loads listed previously. These facilities are not common in such service but are decidedly useful in providing information on plant operations and breaking down



Main transmitter room at Sackville, with portion of CBA broadcast transmitter at the right foreground (on lower level) and the two 50-kw short-wave transmitters at the left and right of the control consoles in the background

operating charges. An engine-driven generator has been provided for emergency use in the event of power failure.

Equipment

Two 50-kw RCA type 7330-A transmitters are located in the building. They utilize high-level modulation and may be operated at any frequency between 6 and 21 mc, at rated output. Their auxiliary equipment, consisting of distribution, plate and modulation transformers, modulation reactor and induction regulators, are located in a large vault in the basement. The installation is generally of standard type. The inter-unit wiring of the transmitters, mainly control, is by metal troughs in the floor slab. All power circuits run in separate conduits and potheads are used on all circuits carrying 2300 volts or more. The circuits carrying high-level audio from the modulation transformer in the basement vault are run in fiber conduit hung on special insulation to reduce capacitance which might affect the feedback loops.

The two operating consoles for the short-wave transmitters have been grouped together between the transmitter fronts. Associated with them are three cabinet-type relay racks containing such equipment as limiting amplifiers, modulation monitors, and feedback amplifiers. Behind these racks are two more racks housing master oscillators of high stability. These provide r-f output at any desired frequency within the range of transmitter operation, and one is connected to each transmitter. The transmitters may be controlled by any one of four self-contained crystals or the master oscillator by operating a selector switch. A secondary frequency standard is provided for use with the master oscillators and to check the crystal frequencies.

The transmitters feed into the antenna switching room. This contains a bank of radio-frequency switches of special design permitting any transmitter to be connected to any antenna (or more properly, transmission line), or to either of two water-cooled dummy loads used for transmitter tests.

The antenna switches are mounted on dead front panels, generally similar to standard switchgear in appearance, and are handwheel operated. The switches are interlocked so that one transmitter can feed only one antenna at a time. Associated with each antenna switch are the controls for the remote reversing and slewing switches for that antenna. Status lights show the operating conditions of each transmitter, whether the particular antenna is operating direct or reversed and also the direction of slew or otherwise. These status lights are multiplied to a panel at the operating console.

The transmitters operate into loads of 415 ohms in this installation and this impedance is maintained throughout the switching and to the r-f bushings in the interior wall of the building. The characteristic impedance is then raised to 552 ohms by a tapered section of line and continues to the antennas in this latter value. Considerable refinement in design was necessary to maintain a constant value of impedance throughout the switching system, for all conditions of switching. This was accomplished, however, and the standing wave ratio is affected to a negligible degree.

A standing wave ratio indicator is mounted in the antenna switching room. It is so arranged that a meter gives a direct scale reading of the standing wave ratio and may be switched into any feed. The transmission lines are generally conventional and of balanced two-wire type. They are constructed of 1/0 stranded copper and carried on suspension-type insulators.

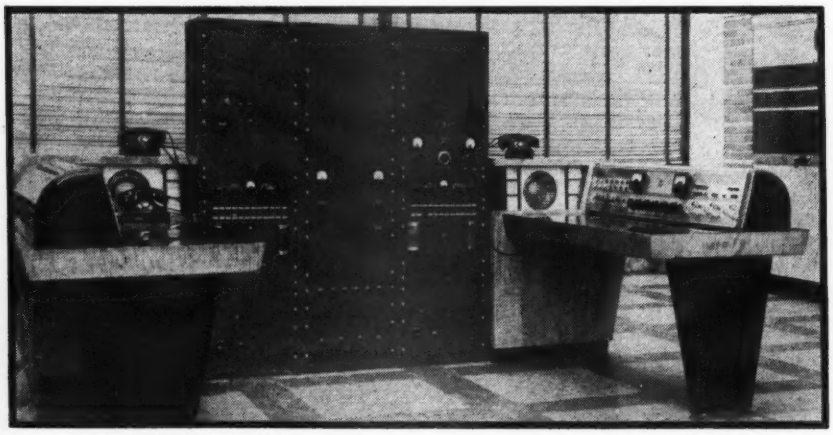
Audio and Program Facilities

A complete unit of the CBC, including program, technical, traffic and administrative staff, was set up in Montreal for international broadcasting. Studios, recording rooms and master control were provided to feed the Sackville plant directly over program lines some hundreds of miles long, provided by Canadian National Telegraphs and Canadian Pacific Telegraphs.

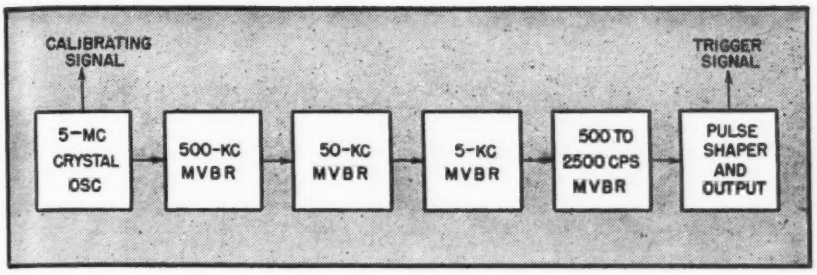
To protect against occasional line difficulties, recording facilities have been provided at Sackville so that programs may be pre-recorded there and stored for a few hours or as necessary. Announce booths have also been provided so that the transmitting plant can operate, for a reasonable emergency period, independently of the Montreal studios.

These requirements, in addition to the normal broadcast and control circuits, led to the provision of a master control at Sackville. This is of the preset type and can handle up to six simultaneous programs. Monitor circuits provide for selection of any incoming or outgoing program as well as the rectified r-f output of any transmitter. Each monitor position can select any of these feeds by a dial selector unit. Monitor positions are located at all transmitter control positions, master control and offices.

The whole plant was planned and designed by members of the engineering division of the CBC, under the direction of the chief engineer, G. W. Olive.



Control consoles for the two short-wave transmitters, with auxiliary equipment in relay racks in background



Time-base calibration requires a constant-frequency calibrating signal and a synchronized pulse to trigger the sweep. A crystal-controlled oscillator provides the calibrating signal; multivibrator frequency-dividers provide the relatively long-period, short-duration synchronized triggering pulses

TIME-BASE CALIBRATION

Time-displacement linearity of oscilloscope sweeps can be measured at tenth-microsecond intervals by using a crystal-controlled, driven multivibrator chain. Circuit provides sweep-triggering pulse and constant-amplitude, continuous calibrating signal

By WALTER W. LUDMAN
Philadelphia, Pa.

TESTING of certain electronic equipment requires the measurement of the width or duration of extremely narrow, rectangular, recurrent pulses. Some of these pulses may have durations as short as one-half microsecond. It may be necessary to measure the duration of such pulses to an accuracy of 2 per cent.

Synchroscope

Measurement of such short-duration pulses is usually accomplished with the aid of a device generally known as a synchroscope. This is primarily an oscilloscope with a triggered sweep circuit supplying, for the horizontal deflecting plates of a c-r tube, a deflection voltage which varies at an unusually high speed and has a very linear rate of change. Provision is made for applying the pulse to be measured directly to the vertical deflecting plates of the c-r tube.

The horizontal sweep voltage or time base varies at a rate such that its total voltage swing may occur in a time interval of only 3 or 4 microseconds; the time between successive sweeps may however be very long in comparison, 1000 microseconds in the example shown in Fig. 1.

The time interval between successive sweeps is controlled by the recurrence rate of the trigger signal which starts the sweep circuit functioning. This trigger signal can be supplied by circuits within the synchroscope or from some external source, but it must be in synchronism with the recurrence rate of the signal to be viewed.

When a pulse having a duration of only one microsecond is viewed on an oscilloscope provided with a sweep having a duration of 3 microseconds, a pattern is obtained as shown in Fig. 2. Very accurate measurements of the actual duration of the pulse at any amplitude can be made if the exact time rate of change per unit of deflection of the horizontal sweep is known. Various methods can be used for calibrating such a time base in terms of microseconds per inch of deflection.

Calibration Techniques

Most calibrating schemes are based on the application of a sine-wave signal of known frequency to the vertical channel of the oscilloscope. If the frequency is known, the time interval between successive cycles of the sine wave is simply $T = 1/F$ seconds or $10^6/F$ microseconds. Thus a frequency of one megacycle would have a time interval of one microsecond between successive cycles.

In order to make use of such a sine-wave calibrating signal it is necessary that the signal be synchronized with the trigger signal which starts the time base. This requirement has led to the general adoption of various forms of shock-excited oscillators. Circuits of this type are arranged to deliver a damped wave train of oscillations when excited by the same trigger voltage which initiates the sweep oscillator. The time interval between successive cycles of the damped wave is governed by a tuned circuit which is resonant at the desired frequency.

The disadvantages of this method are: (1) Since the frequency is determined by a simple tuned circuit, its alignment must be checked frequently. (2) The frequency of the tuned circuit can only be checked while it is operated in a continuous-wave oscillator circuit. Whether the resonant frequency remains the same under conditions of shock ex-

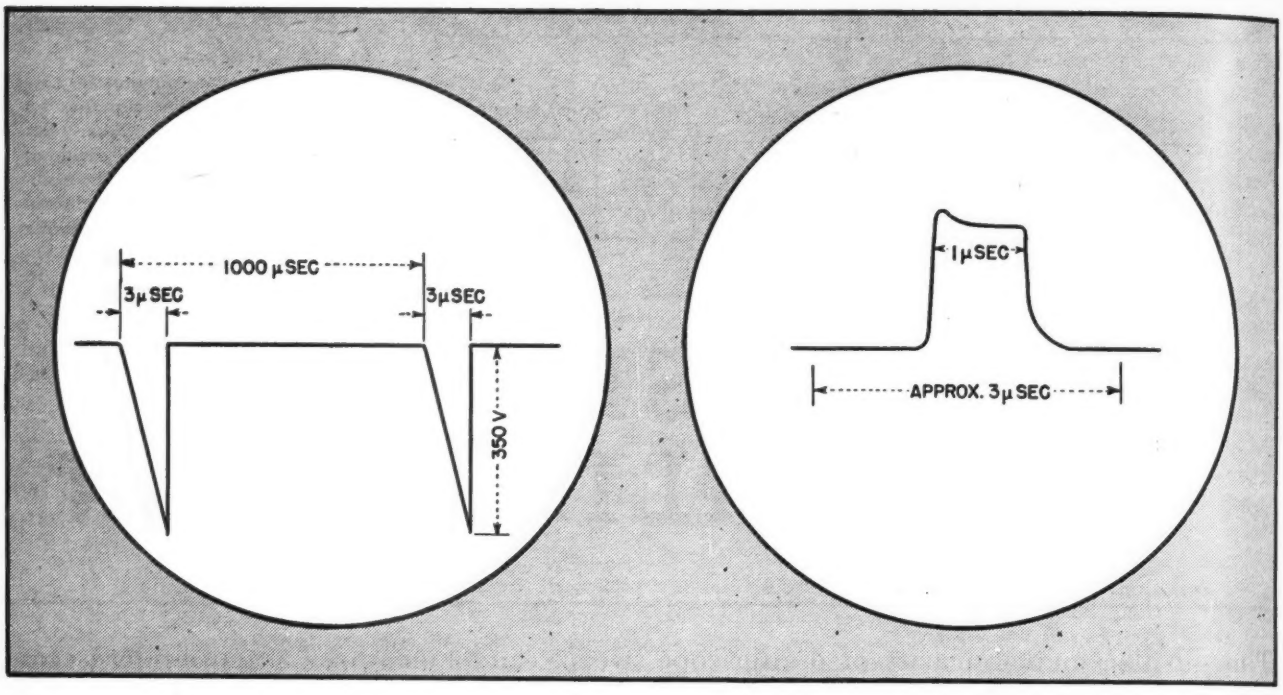


FIG. 1—Typical pulse sequence, showing the long and short periods that must be accommodated by a time-base calibrator

FIG. 2—One-microsecond pulse can appear distorted when viewed on a high-speed time base if the sweep is non-linear

citation is questionable. (3) A damped wave train may introduce errors because the time interval of each cycle is not the same.

To overcome these drawbacks the system shown in the block diagram is used. The unit contains a 5-mc crystal-controlled oscillator which supplies the calibrating signal. Because the time interval between cycles is 0.2 microsecond, calibrating intervals of 0.1 microsecond are readily available.

Following the crystal oscillator is a series of multivibrators used as frequency dividers. The first, operating at 500 kc, is synchronized directly from the crystal oscillator. It, in turn, synchronizes a 50-kc stage which in turn locks in a 5-kc multivibrator. The output of this multivibrator synchronizes a fourth, whose frequency is variable in synchronized steps from 500 to 2500 cps.

The output of the last multivibrator is fed through a pulse-shaping amplifier, a variable delay network and finally a cathode-loaded output stage. The function of the frequency dividers and pulse-shaping stage is to produce a pulse which is synchronized with the calibration signal and suitable for use as a trigger pulse to trigger the sweep circuit in the oscilloscope.

When the oscilloscope sweep is triggered by this pulse and the calibrating signal from the crystal oscillator applied to the vertical plates of the c-r tube, the stationary sine wave pattern of Fig. 3 is obtained. The variable delay control in the input to the cathode-loaded output stage permits positioning the calibration signal anywhere along the time base.

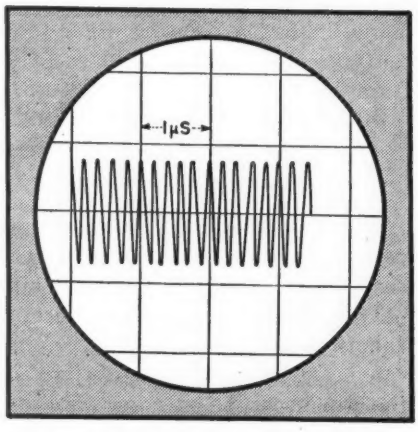


FIG. 3—Constant-amplitude, fixed-frequency sine wave serves to mark microsecond intervals on sweep for linearity calibration

As previously pointed out, the time interval between successive peaks of the same polarity is 0.2 microsecond. If the sweep speed is adjusted until exactly five peaks coincide with one inch of deflection, the time base can be considered to have an accurate calibration of one microsecond per inch of deflection. If the sweep speed is adjusted for 10 peaks per inch, the calibration is equivalent to 2 microseconds per inch.

Calibrator Circuit

The circuit shown in Fig. 4 is, with few exceptions, straightforward and requires little explanation. The final multivibrator is made variable in frequency so that the oscilloscope sweep circuit can be triggered at the same repetition rate while being calibrated as when being used for measurements. This multivibrator is also of the unbalanced variety, i.e., the circuit constants of the two sections of the dual tube comprising the multivibrator are considerably different. As a result, one half-cycle of the signal is much shorter in duration than the other half. This permits obtaining a pulse of comparatively short duration. Because the shorter part of the cycle appears as a negative pulse on the plate of the left-hand triode, the output of this section is applied to a zero-bias amplifier which permits the negative half-cycle to be amplified while tending to clip the positive half-cycle. The amplitude of the negative peak is sufficient to drive the amplifier grid to cutoff thus squaring the peak.

The combination of the 25,000-ohm rheostat and 15-$\mu\mu$f capacitor produces a phase shift which is capable of making the signal applied to the grid of the cathode-loaded stage lag the signal at the plate of the preceding tube by almost one microsecond.

The output signal is a positive pulse having an amplitude of approximately 20 volts peak and a duration at 80 percent of peak of about 12 microseconds. The output of the crystal oscillator is approximately 70 volts peak to peak.

Use of Calibrator

To insure utmost accuracy of calibration and measurement certain precautions have to be observed. First, before the time base is calibrated, the sweep should be positioned by means of the position control so that the start of the sweep is at some definite reference point. Once this adjustment is made and the calibration performed for this setting, all measurements should be made with the sweep starting at the same reference point.

Second, when calibrating the time base, the calibration should be made for a certain definite portion of the sweep (usually the one inch nearest the center of the oscilloscope). All future measurements should then be made on the same portion of the sweep. These two precautions eliminate possible error due to non-linearity of the sweep or non-linearity of the c-r tube deflection.

Also, it is advantageous to use the peaks of the calibration signal which are nearest the vertical portion of the c-r tube face used in making measurements. Thus if negative pulses are to be measured on the scope, the negative peaks of the calibrating signal would be nearest to the portion of the tube face on which the measurement is to be made. If measurements are made at the vertical center of the screen, it may be an advantage to use the zero crossover portion of the sine wave.

Advantages of Calibrator

The equipment described has certain desirable features not found in calibrators using such methods as triggered shock-excited oscillators. First of all, because the calibration signal is crystal-controlled and operates continuously, the calibration signal covers the entire duration of the sweep and has a constant amplitude over the whole sweep.

The use of a 5-mc calibrating signal enables the calibration of the sweep to be done at points of one microsecond and one-half microsecond per inch of sweep with high accuracy. The unit can also be easily adapted to the calibration of slower speed sweeps by utilizing the output of the intermediate multivibrators for a calibrating signal. For example, the 500-kc multivibrator could be used for obtaining 2-microsecond time intervals, 20-microsecond points can be obtained from the 50-kc multivibrator and 200-microsecond intervals from the 5-kc multivibrator.

To make use of the intermediate frequencies for calibrating purposes it would be desirable to pass the output of the multivibrator through an amplifier which has a differentiating network in its grid circuit. This practice would provide sharp, spike-like pulses that would permit sharper calibration.

In setting up the unit and adjusting the multivibrators to synchronize on the proper frequencies a single or multiple loop Lissajou pattern can be produced on an oscilloscope by using the multivibrator output and a standard signal generator. The dual potentiometer in the grid circuit of the multivibrator is varied until the Lissajou pattern is synchronized; that is, appears stationary. An alternate method is to use the output of the crystal oscillator or the preceding multivibrator in place of the signal generator. The final multivibrator can best be checked for frequency range by comparing its output to an audio-frequency signal on the oscilloscope.

Units of this type have been in use by the writer for several years for calibrating oscilloscopes. The results have been consistently reliable. Few readjustments of the multivibrators have been necessary.

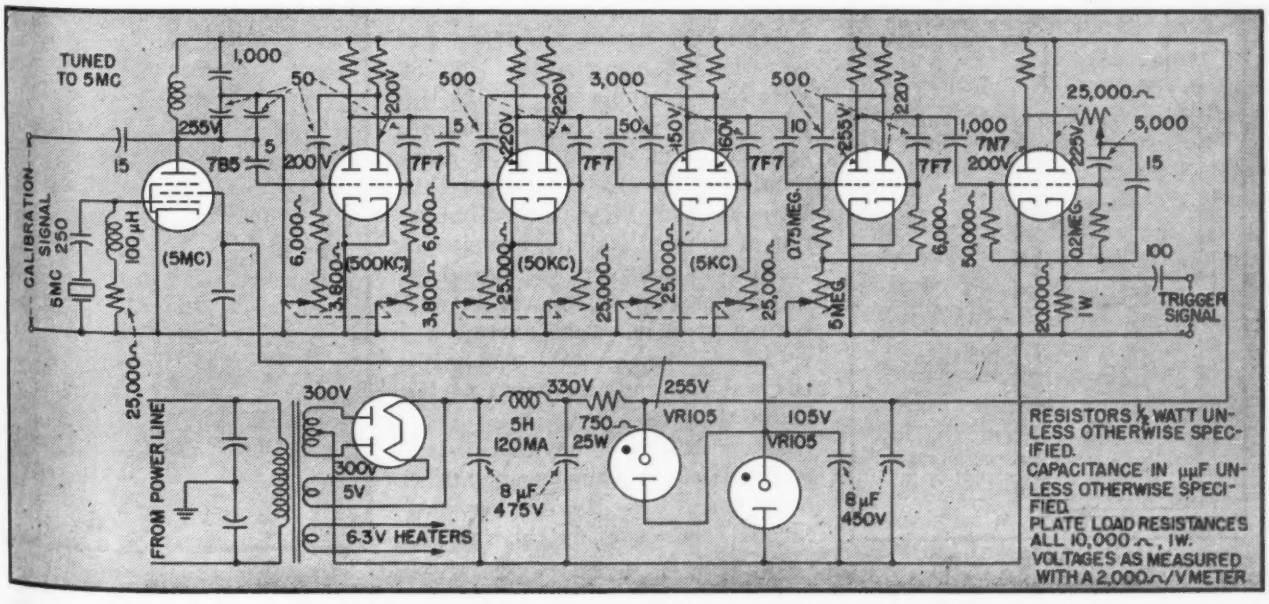


FIG. 4—Circuit of self-contained time-base calibrator which can be built for rack mounting or test-bench use

Electronics Aids

Breakwater, levee, dam, lock and other marine experiments performed with models utilize electron tubes for the determination of wave heights and water pressures. Earth pressures are recorded in a manner which lends itself to the testing of airport runway pavements. Special relay-booster and timing circuits are also used

By EUGENE H. WOODMAN
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Vicksburg, Miss.

ONE OF THE AGENCIES of the Corps of Engineers, War Department, which has consistently done its part toward victory is the U. S. Waterways Experiment Station. Established in 1929 for the primary purpose of making hydraulic model studies of the Mississippi River and other recalcitrant streams and, through an associated soil mechanics laboratory, making improvements in levee and dam design, the activities of this agency have more recently been devoted to problems of harbor protection and improvement and airport design as well as other related investigations concerned with the war effort.

One of the most important adjuncts of this investigative agency lies in the instrumentation developed for specific requirements dictated by the complex techniques employed in the solution of modern hydraulics and soil mechanics problems. It is the purpose of this paper to describe some of the electronic devices which have recently found application in the successful solution of several difficult problems. The instrumentation to be described includes wave-height measuring apparatus for breakwater and harbor studies, pressure cells designed to determine both water and earth pressures, deflection gages used in pavement studies, and timing apparatus for velocity determination by means of float measurements. Other devices in use or under development are briefly mentioned.

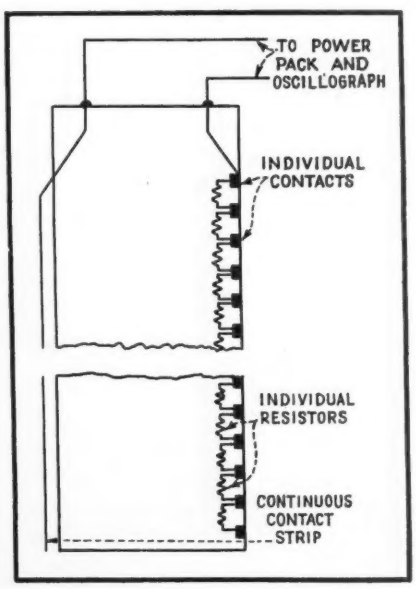


FIG. 1—Schematic of a staff which facilitates determination of wave heights. A photograph of the staff is shown in Fig. 2

Wave-Height Measurement

While the device developed for wave-height measurement is not strictly electronic in itself, the power unit supplying the necessary constant d-c voltage is electronically controlled. It is this latter refinement, with its elimination of frequent calibrations necessitated by battery voltage drop during periods of operation and battery rejuvenation during periods of idleness, that has made the wave-height measuring device a practical tool.

Essentially, this device consists of a vertical staff or case containing a series of individual contacts in one face, covering the vertical range of water movement expected, and a continuous contact on the opposite face, as illustrated in Fig. 1. Small (½-watt) resistors are interconnected between the individual contacts. These resistors are contained within the case, as shown in Fig. 2, except when limited by reduced physical dimensions of the cases used on small-scale models, where closer contact spacing and a small cross-sectional area are necessary because of diminutive characteristics of the wave patterns. In such instances, the resistors are mounted on a cross-arm located above high-water elevation and the interconnections to the individual contacts are made with small-gage wires running up through the case to the cross-arm.

The principle utilized in the wave-height measuring device involves the fact that a water path can serve to complete an electrical circuit between two points (in this

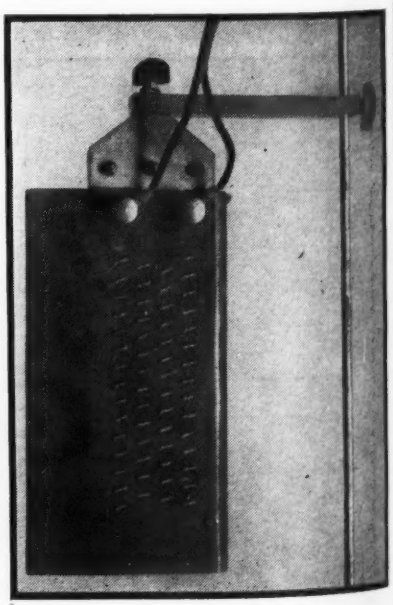
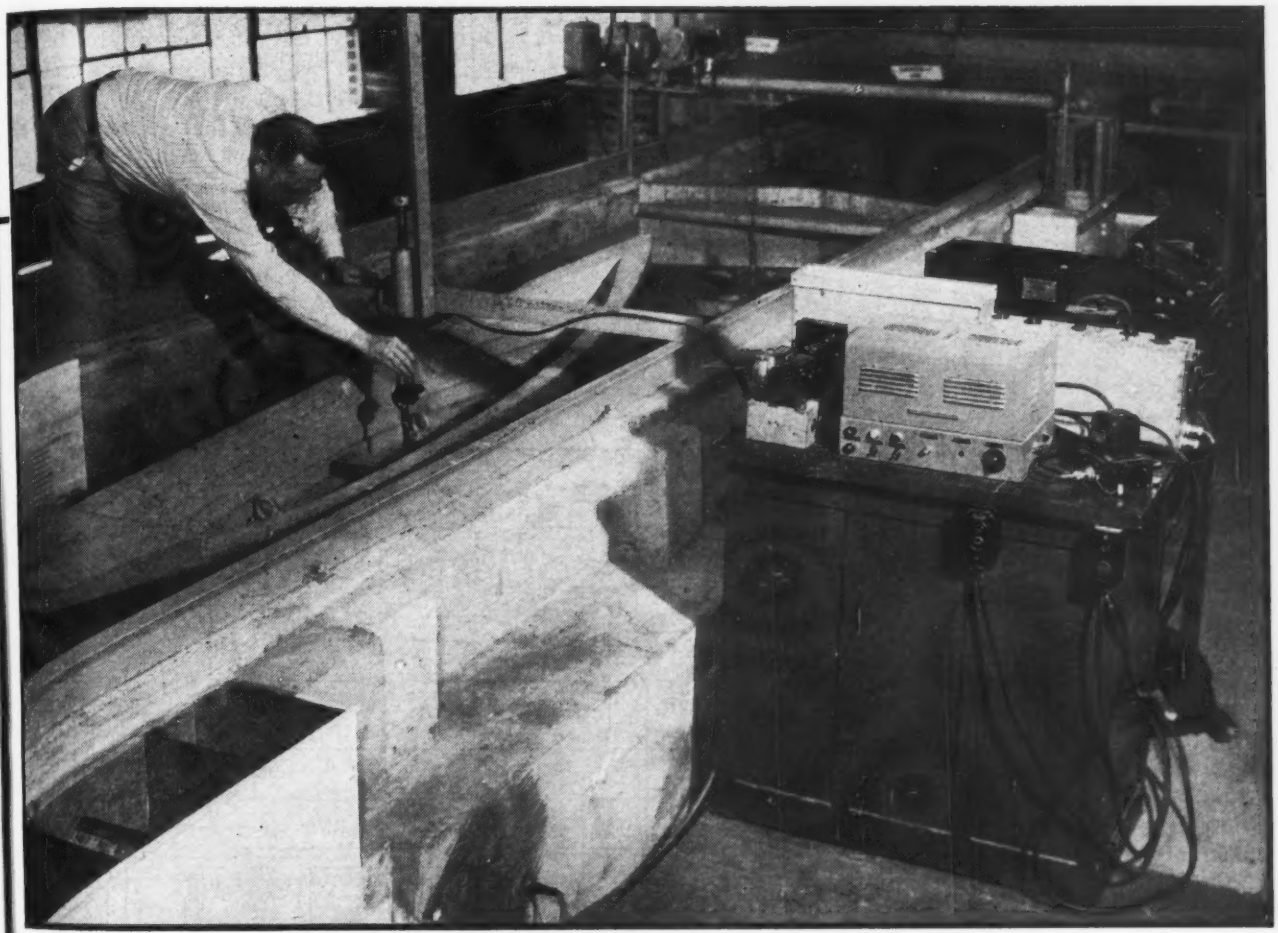


FIG. 2—Photograph of the wave-height measuring staff shown schematically in Fig. 1. Resistors are within the staff and their leads form contacts

Waterway Development



Resistance-wire strain gages and associated electronic equipment measure hawser pull on a model ship entering a canal lock

instance, the continuous contact strip on one face of the case and whichever of the individual contacts on the other face is located on the water surface at that instant). The resistance of this electrical circuit can be made to vary in inverse proportion with variations in the water-surface elevation by suitable calculation of the individual resistors installed between contacts. Thus, when a constant d-c voltage is impressed across the terminals of the resistance staff, the resulting current changes in the electrical circuit will correspond directly with changes in water-surface elevation, or wave height.

The calibration curve shown in Fig. 3 represents the oscillograph deflections obtained in calibrating a wave-height measuring device with a 2½-foot range. This calibration was obtained by making incremental variations of the submergence of the resistance staff in still water and observing the corresponding deflections of the galvanometer beam. It should be noted at this point that a continuous curve is obtained on the oscillogram as the resistance staff is moved through its range in the water. Although in theory a stepped record would be obtained as determined by the spacing of the individual contacts, in actuality the variation in contact area as the staff is submerged is sufficient to result in a practically continuous curve. Resistance of the water path remains fairly constant throughout the operating range; any possible error from this variable and from changes in the conductivity of the water is eliminated by the use of a current-limiting resistor included in the calculations of individual resistor values; it has not been found necessary to add salt to the water or otherwise alter its natural conductivity.

A constant d-c voltage must be impressed on the terminals of the resistance staff. It is obvious that this device is voltage-sensitive in regard to calibration. It was found in practice that there were slight irregularities in the output of a conventional power supply operating from the a-c lines, even when voltage regulator tubes were used. Futhermore, the output of such a device contained traces of 60 and 120-cycle voltages and their harmonics, even with an oversized double-section filter, and the device was affected by transients in the a-c supply. Accordingly, several electronically operated voltage-stabilizing circuits were investigated and a satisfactory circuit developed. The circuit as finally evolved was an adaptation of the

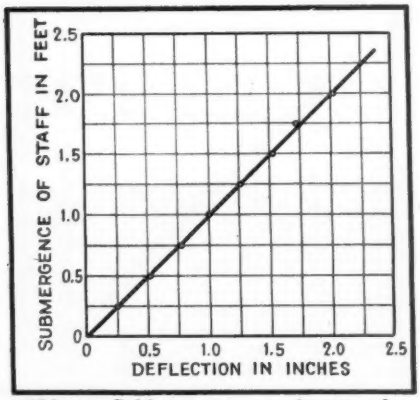


FIG. 3—Calibration curve showing deflection in inches on the screen of an oscillograph versus submergence of a wave-height measuring staff in feet

voltage stabilizer controlled by a thermionic pentode described by Evans[1], operated in conjunction with a gaseous voltage regulator tube rated at 90 volts. The complete circuit is shown in Fig. 4. This circuit provides an output voltage of extreme stability, completely protected from a-c transients and long-time surges. The resulting straight trace on the oscillogram is indistinguishable from a d-c battery trace even when the equipment is operating at full sensitivity. As a matter of fact, the calibrations obtained with this device have been found to be so consistent that it is now necessary to calibrate the resistance staffs themselves only at more or less infrequent intervals; for this reason an artificial calibrating arrangement has been added to the equipment in order to facilitate setting and checking galvanometer sensitivity for waves of various heights.

A block diagram of the complete wave-height measuring apparatus is shown in Fig. 5. All of the component parts described in the paragraph above are contained in a single chassis assembly, the only external connections being the input lead from the resistance staff, the output lead to the oscillograph, and the connection to the a-c line. For use on a wave-action model, as many of these assemblies as may be required, depending on the number of points of wave-height measurement to be recorded simultaneously, are placed in a rack at the point of recording. A group of five of these devices so assembled is pictured in Fig. 6. Oscillographic recording is employed because of the short wave period (1 to 3 sec) of the model waves encountered. For waves of a longer period a recording meter could be connected in place of the oscillograph with equivalent results.

Water-level variations ranging from 10 feet down to less than 0.01 foot have been measured with various physical versions of the wave-height measuring device, and no difficulty is foreseen in extending this range in either direction. The staff can be made of sufficient length to extend below the trough and above the crest of the maximum wave to be measured, and the cross-section may be as large as is necessary to secure the desired rigidity. A three-foot resistance staff has been operated in the Experiment Station lake for experimental purposes. In this installation, a recording milliammeter was employed, together with a system of relays to control the interval and length of records taken. This relay circuit was interconnected with two trigger elements mounted on either side of the resistance staff in order that storm waves not in coincidence with the set intervals of wave recording would not be missed, with the intervals between recordings being successively reduced as the heights of the waves exceeded the values for which the triggers were set.

Prototype applications of this device in lakes or even the ocean

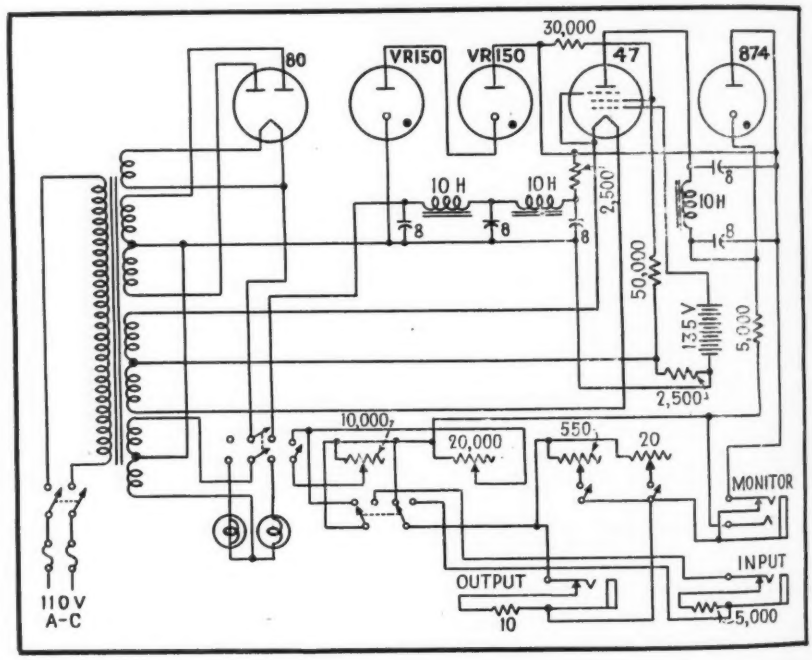


FIG. 4—Voltage-stabilized power supply used in conjunction with wave-height measuring equipment. Provision for setting and checking galvanometer sensitivity is included in this circuit to insure maintenance of calibration

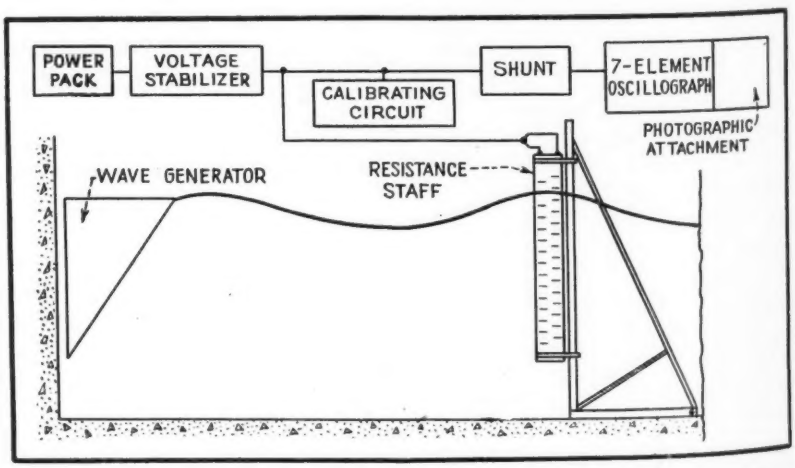


FIG. 5—Block diagram of the complete wave-height measuring apparatus

have been given consideration. The staff could be attached to an existing nonfloating structure such as a fixed channel marker or a breakwater, or to a substantial pile or pile clump driven at the desired location, while if excessive depth precluded erection of a fixed structure on which to mount the staff an appropriately anchored floating rig would suffice. Wave-height measurements from these installations could easily be relayed by radio to recording meters located on shore or elsewhere. It is believed that the resistance staff can be adapted readily to the measurement and recording of full-size waves.

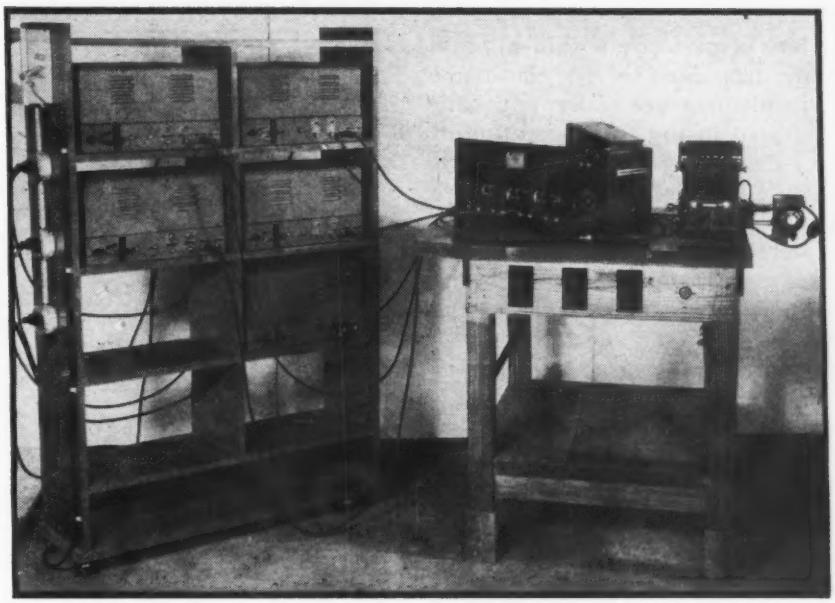


FIG. 6—Five wave-height measuring units may be seen in the portable rack, with an oscillograph at the right

Determining Wave Pressure

Eight pressure cells were supplied by a commercial firm in accordance with specifications. The simplest single-channel setup includes a pressure cell, an attenuator, a one-stage amplifier, a rectifier and filter, an oscillator, and a power supply. These components constitute a modulated a-c bridge as shown in Fig. 7.

The pressure cells or gage heads have a range of 0 to 1 psi when in their most sensitive adjustment. This range may be attenuated in the amplifier input circuit to a range of 0 to 8 psi. The pressure cell is approximately two inches in diameter and four inches long, and consists of three essential parts: the diaphragm, the cell body, and the coil holder. Construction is shown in Fig. 8. The diaphragm, fastened to the gage body, carries an armature which transforms the diaphragm movements caused by pressure into changes of reactance of the coil. A second coil in the unit, known as the balancing unit, remains at a constant reactance, at a value determined by adjustments made during calibration. The two coils are so interconnected in the a-c bridge arrangement that any movement of the armature due to pressure will cause a voltage change in the amplifier input circuit. The a-c voltage is amplified, rectified, and filtered. The final result is a direct-current output proportional to the applied pressure. By connecting a recording oscillograph to the output, dynamic records of water pressures under any desired conditions of operation are obtained.

The pressure cells just described were secured originally for the study of wave force against breakwaters, in which it was necessary to determine the pressures exerted by the waves at various elevations in order to develop vertical pressure curves for use in future design problems. Figure 9 shows a special model breakwater section equipped with pressure cells and wave-height measuring contacts. The cells were soon found to be ideally suited to other applications. One of the more interesting was in the study of pressures due to water hammer in a model of the Fort Peck Dam power tunnel.

Pressure cell equipment has been successfully adapted to supply another long-needed apparatus —a device for recording rapid fluctuations of pressure in hydraulic systems in which conditions do not permit installation of a cell at the point of measurement. An instrument for measuring instantaneous

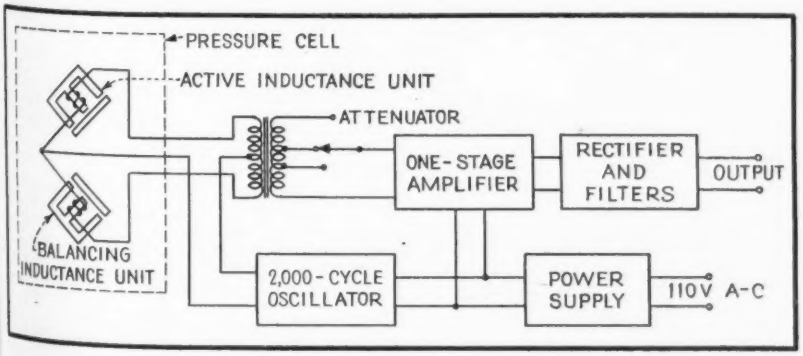


FIG. 7—Block diagram of a-c bridge circuit used to determine wave pressure exerted against model breakwaters, dams and other marine structures. The two inductance units shown within the dashed lines constitute the pressure cell shown in Fig. 8

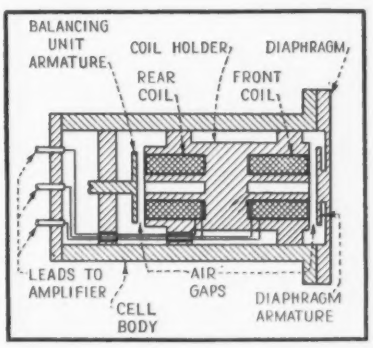


FIG. 8—Gage head or cell employed in the determination of wave pressure. Two such cells may be seen in the photograph of Fig. 9

values of pressure within a liquid body has been given the name dynamic pressure meter, and is illustrated in Fig. 10. Operation of this device depends upon the hydraulic principle that the pressure impulse at the small opening in the probe will be transmitted practically undiminished through the confined liquid to the face of the pressure cell. The device is sensitive to the rapid pressure fluctuations long known to exist in pump intakes and around baffle blocks below dams. Such measurements have been impossible to secure with the open-well piezometers

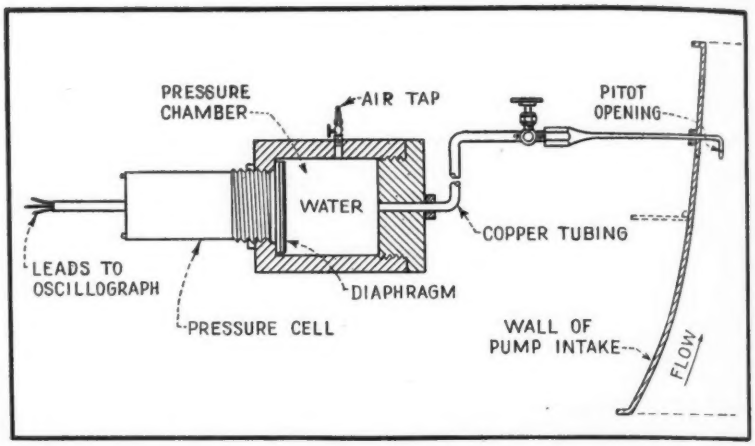


FIG. 10—Method employed to record rapid fluctuations of pressure in hydraulic systems, using one of the pressure cells designed to measure wave pressures. This particular device is called a dynamic pressure meter

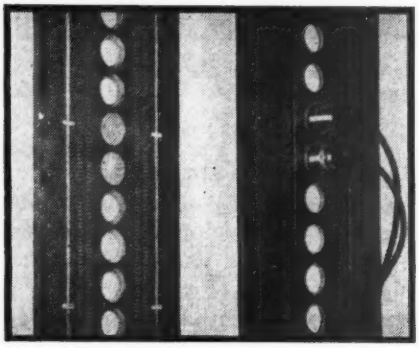


FIG. 9—Model breakwater section equipped with cells such as the one illustrated in Fig. 8 for the measurement of wave pressure, and contacts such as those illustrated in Fig. 1 and Fig. 2 for the determination of wave height

previously employed due to their inherent unresponsiveness to rapid pressure fluctuations. The dynamic pressure meter has been adapted to a wide range of uses involving measurements of both dynamic and static pressures.

Recording Earth Pressures

The pressure cells described are only one of several types employed. Various applications, both for model work and in the field, have involved the use of many of the well-known pressure-responsive elements such as Goldbeck cells, Carlson stress meters, and SR-4 resistance strain gage cells. The principal activities of the Experiment Station have been in the development of cells utilizing resistance-wire strain gages and associated electronic equipment. This equipment has been used for studying settlement pressures in earth-filled dams, for pressure distribution studies in connection with airport pavement design, for field measurements of penstock water-hammer pressures, and for other similar applications. Both direct-current (direct coupled) and alternating-current types of amplifiers have been developed for use in connection with these pressure cells.

Figure 11 shows a typical field installation for dynamic measurement of earth pressures, in which six direct-current amplifiers were employed. In this application it was considered necessary to use direct-current amplifiers due to the high-frequency shock pressures to be recorded. The circuit for these amplifiers was based on the circuit described by Trevino and Offner[2]. For other applications it has been possible to use alternating-current amplifiers, and a more or less standard circuit has been developed for this equipment, which includes a 2000-cycle oscillator to supply bridge voltage, a three-stage amplifier, rectifier, and filters. A block diagram of this equipment is presented in Fig. 12.

Pressure cells for hydrostatic measurements are somewhat simpler in construction than the earth pressure cells, and this type of cell will therefore be described first. The basic element employed in these devices is the SR-4 resistance wire strain gage, which consists of a grid of very fine resistance wire assembled on a thin layer of paper, with suitable protective felt covering. In practice this gage is cemented to a metal diaphragm and functions by virtue of the fact that strain in the diaphragm resulting from bending due to applied pressure will result in strain in the wire grid sufficient to pro-

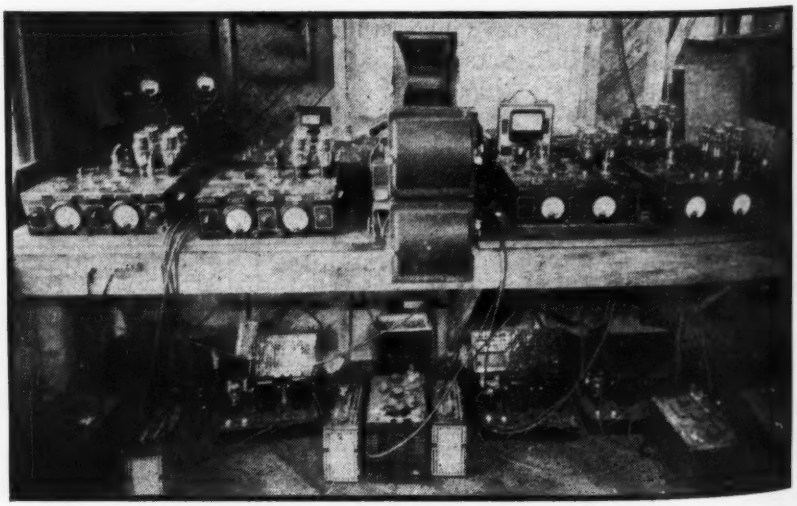


FIG. 11—Field installation of resistance-wire strain gage equipment designed to measure earth pressures. One of its uses was in connection with the design of bombproof shelters. In this instance d-c amplifiers were used

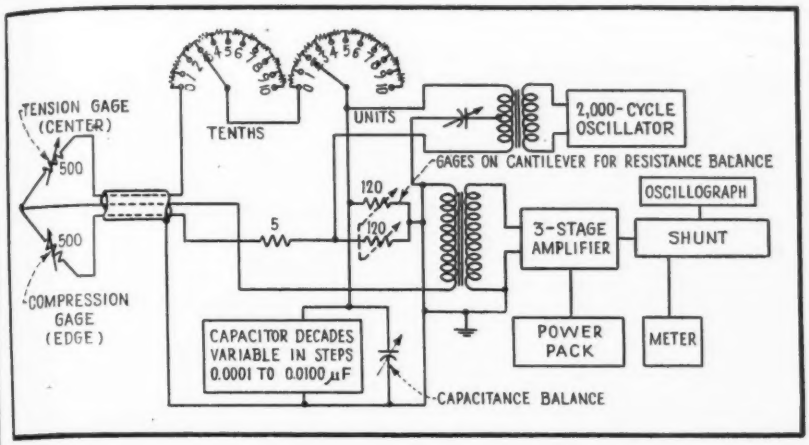


FIG. 12—Block diagram of a-c bridge circuit used in conjunction with resistance-wire strain gages for the measurement of earth pressures

duce a change in the resistance of the wire. It is this change in resistance, previously correlated with pressure applied to the diaphragm, which provides a measure of the pressures under observation. Temperature compensation is secured by mounting a second strain gage on a portion of the cell not subject to strain, or in some cases so mounted on the edge of the diaphragm that compression occurs as pressure is applied. In either case, this compensating gage is connected in an arm of the input bridge in opposition to the tension gage as shown in Fig. 12, which results in cancellation of strain changes in the material due to temperature variations.

Constructional details of the hydrostatic cell are shown in Fig. 13. Note the active gage mounted on the machined diaphragm, the temperature-compensating gage mounted on a metal shelf above it (not subject to strain due to pressure), and the three-conductor cable brought out of the rear of the cell through a water-tight packing nut. The face of the cell is covered by a sand screen to exclude earth from intimate contact with the cell diaphragm in cases where the cell is installed in earth dams for measurement of pore pressures. Other applications of this cell have included investigation of micro-turbulence and macro-turbulence on the bed of the Mississippi River.

The earth pressure cell differs from the hydrostatic cell in that pressure does not act directly on the diaphragm. In this type of cell the pressure is applied to a machined faceplate which is connected to the cell body through a flexural ring milled in its periphery. The space between the face plate and the diaphragm is filled with transformer oil under low pressure. This construction insures that any uneven pressure applied to the faceplate will be uniformly applied to the diaphragm.

The six-channel amplifier shown in Fig. 14 is typical of the electronic equipment provided for use with pressure cells or other de-

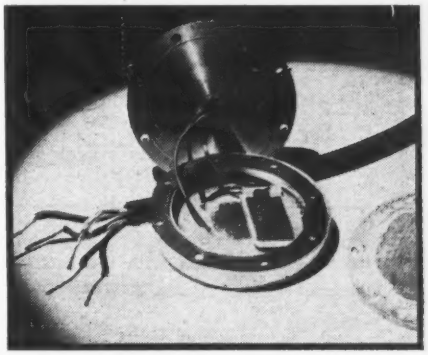


FIG. 13—Photo showing constructional details of a hydrostatic pressure cell. The active resistance-wire strain gage element is mounted on a machined diaphragm subject to flexure by pressure, while a temperature-compensating gage element is mounted on a shelf which is not subject to such flexure

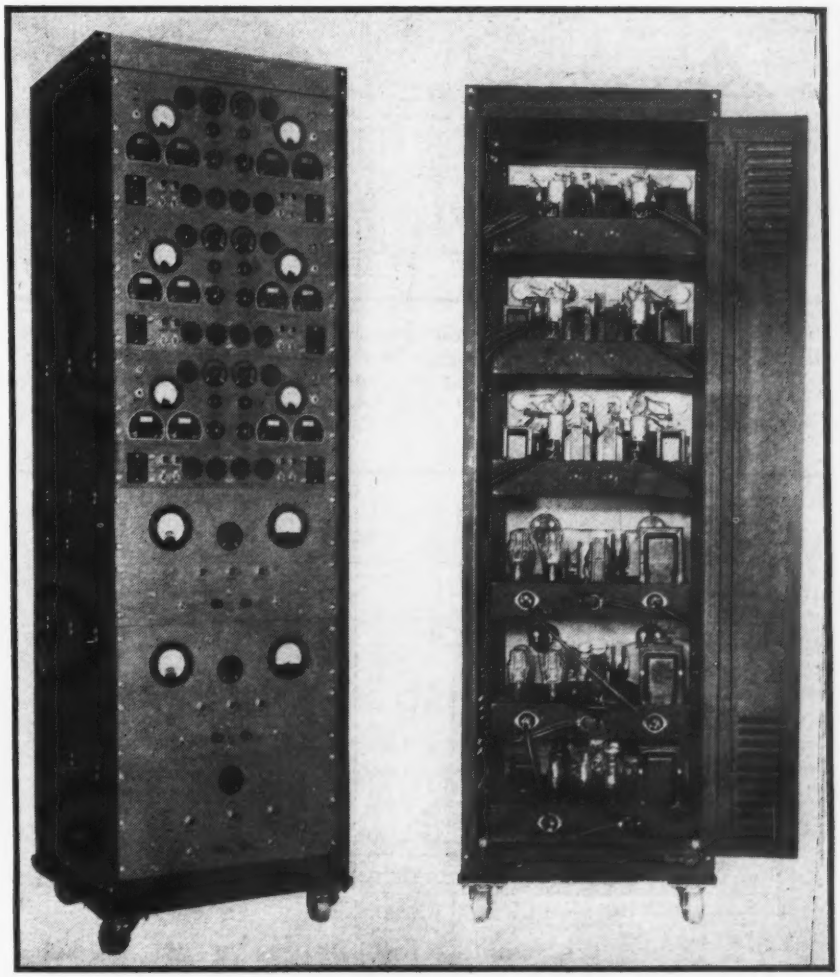


FIG. 14—Two views of a six-channel amplifier used in conjunction with pressure cells or other devices containing resistance-wire strain gages

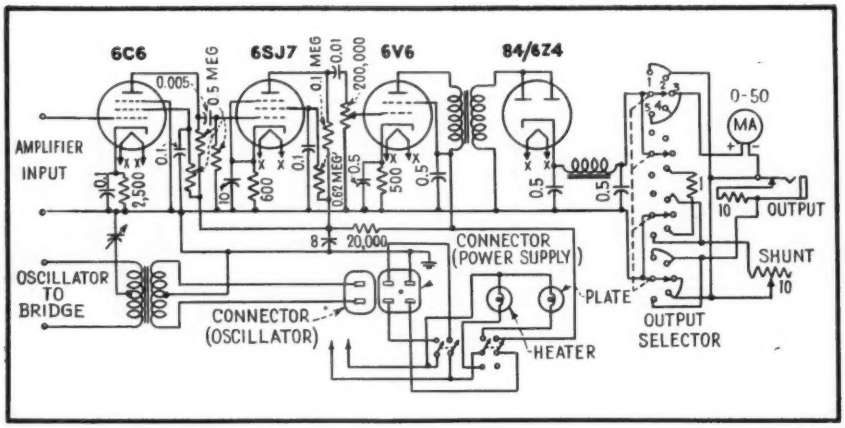


FIG. 15—Circuit of three-stage amplifier employed in the unit pictured in Fig. 14. It is used in conjunction with the oscillator shown schematically in Fig. 16 and the power supply shown in Fig. 17

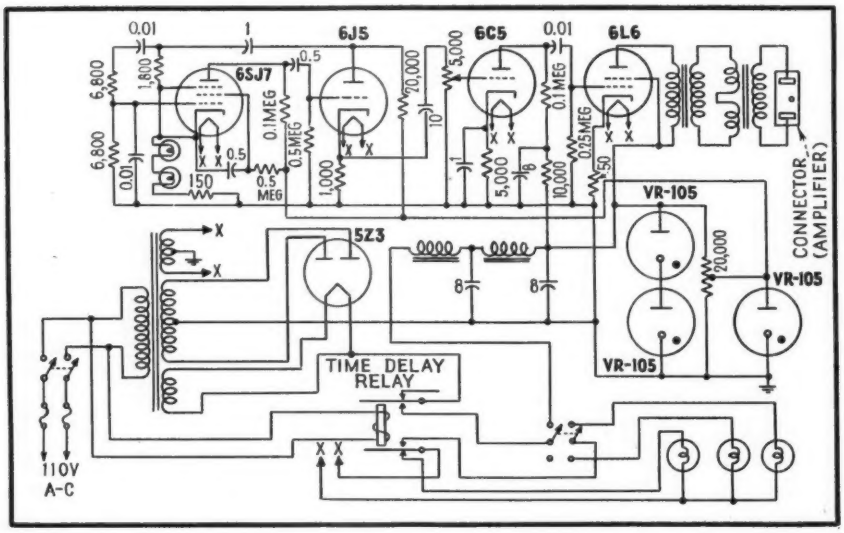


FIG. 16—Resistance-controlled 2000-cycle oscillator used in combination with amplifiers such as the one shown schematically in Fig. 15. It supplies power to six a-c bridges, the output of which drives associated amplifiers and oscillographs

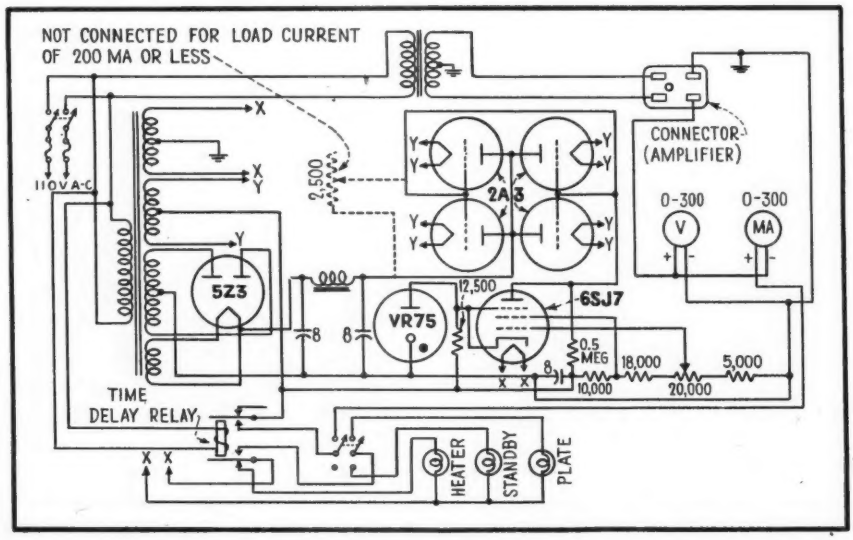


FIG. 17—Electronically-stabilized power supply used with amplifiers such as the one shown in Fig. 15

vices containing resistance strain gages as the measuring element. The detailed circuit for a typical three-stage amplifier is presented in Fig. 15, including the rectifier, filter, and output selector connections. The 2000-cycle oscillator diagram is shown in Fig. 16. A resistance-controlled circuit was selected for stability. The buffer stage serves to divorce the oscillating circuit from load changes, and the power stage supplies the necessary output for operating six bridge circuits. The electronically regulated power supply is shown in Fig. 17. This circuit provides a constant plate voltage for each amplifier channel, unaffected by line transients or load changes.

In operating the equipment, each input circuit is brought to a resistive and capacitive balance and the oscillator voltage, individual channel gain, and output shunt are adjusted for the desired attenuation as determined by the resistance change expected. Calibration, in terms of resistance change, is then accomplished by means of the decade resistance units incorporated in the input circuit.

The particular equipment just described was designed for use on airport pavement tests for determining pressure distribution in the subgrade and for measuring pavement deflections. For the former measurements the earth pressure cell is used, while for the latter measurement a special deflection gage has been developed. This device employs the SR-4 gage as the measuring element, but in this case strain is produced in the gage by movement of a cantilever arm on which the gage is mounted. Movement of the cantilever arm is produced by a tapered pin which is displaced as the pavement deflects under load. Constructional details of this gage are shown in Fig. 18. This gage is installed in the surface of the pavement as shown in Fig. 19.

Both the pressure cells and deflection gages employing the resistance strain gages have a linear characteristic over their operating range. Figure 20 is a calibration curve for a deflection gage with a 0.3-inch range. This curve was obtained by making incremental offsets on the gage and com-

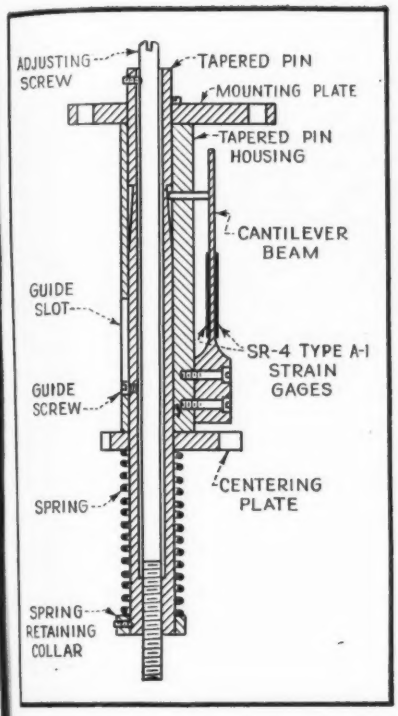


FIG. 18—Details of a gage used to measure pavement deflections

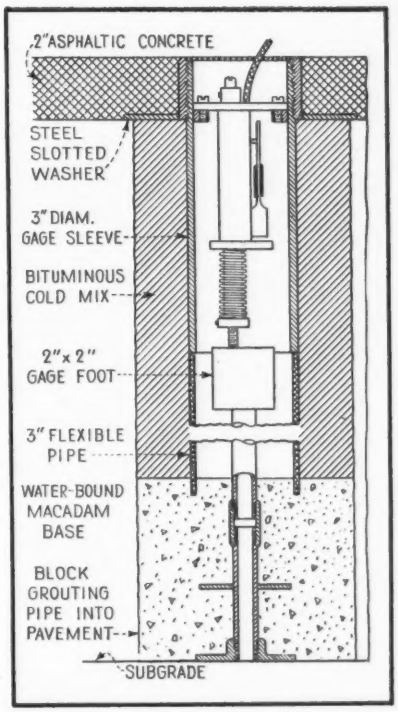


FIG. 19—Method of installing the gage illustrated in Fig. 18 in pavement

puting resistance changes from readings required to balance a special Wheatstone bridge designed for use with these gages. In operation, the amplifier is calibrated as previously explained by recording 0.1-ohm resistance changes on the oscillogram. This calibration is then used in conjunction with the gage factor stated on the calibration curve as a means of interpreting the deflection records obtained during load passages over the pavement. The oscillogram in Fig. 21(A) illustrates the calibration method just described, while the oscillogram in Fig. 21(B) shows a typical record obtained from pressure cells installed in an airport pavement test.

Other Electronic Applications

Circuits involving thyratron tubes have been developed for a number of applications. For example, on all models involving the simulation of tidal action, a rather complicated cam-operated apparatus has been developed for automatic and continuous reproduction of the tidal cycle. Irregularities in operation of this equipment were traced to floating control contacts, at which point inevitable surface corrosion film was causing erratic closing of control relays. Insertion of a thyratron-operated booster relay in the floating contact circuit has completely alleviated this difficulty.

A typical booster-relay thyratron circuit as employed on tide-control equipment is shown in Fig. 22. The grounding polarity light is incorporated as a ready means of determining proper polarity in plugging in the equip-

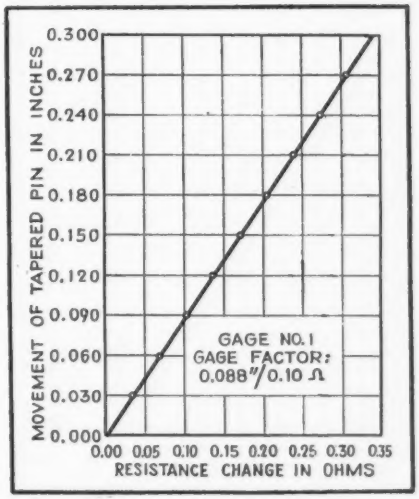


FIG. 20 — Deflection-gage movement versus resistance change in ohms

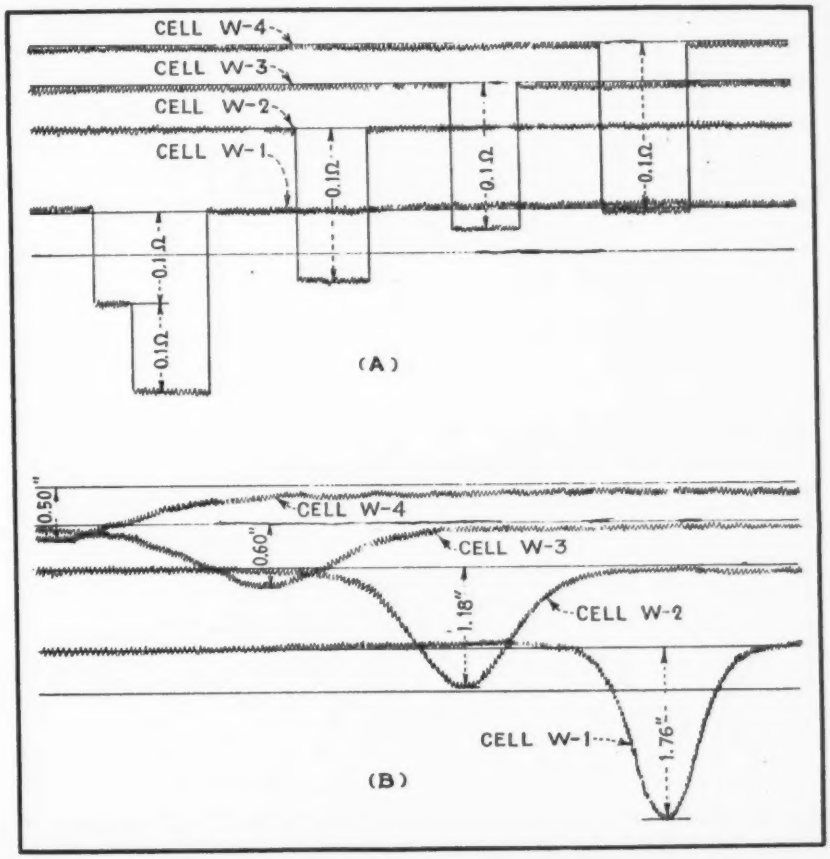


FIG. 21—(a) Oscillogram illustrating the method of calibrating a deflection gage explained in the text. (b) Typical record obtained from a deflection gage installed in the pavement of an airport runway

ment, which is frequently moved about, since proper and foolproof grounding of the equipment is considered essential due to its customary use in proximity to bodies of water. The transformer, rectifier, and filter provide a steadier operating condition for the thyratrons than could be obtained with straight a-c operation, and were incorporated for this reason. The indicating lights were included as a visual aid to the operator during adjustment of the tidal apparatus.

Another thyratron-controlled relay circuit has been developed for timing the passage of floats between fixed points in model discharge ranges and has proved to be much more accurate than previous manual timing methods. The problem here was to start a stop-watch as a float passed under a wire at a certain point and to stop the watch as the float passed another wire, say 12 inches downstream from the first wire. This is accomplished in the circuit shown in Fig. 23.

Passage of a metallic float under a cat-whisker wire produces a momentary high-resistance contact sufficient to fire the thyratron tube and its associated relay. This operation starts the electric stop watch, locks out the relay circuit for a fraction of a second to prevent any effects from bouncing of the float on the initial contact, and then sets up the relay circuit to drop out on the next contact. Passage of the float under the second cat-whisker wire results in stopping of the stop-watch, temporary locking out of the relay circuit as explained above, and then restoration of the relay circuit to the starting condition. This circuit makes it necessary to use only one lead wire from the contacting frame to the thyratron circuit, which enables the operator to make a very sensitive adjustment of the operating point.

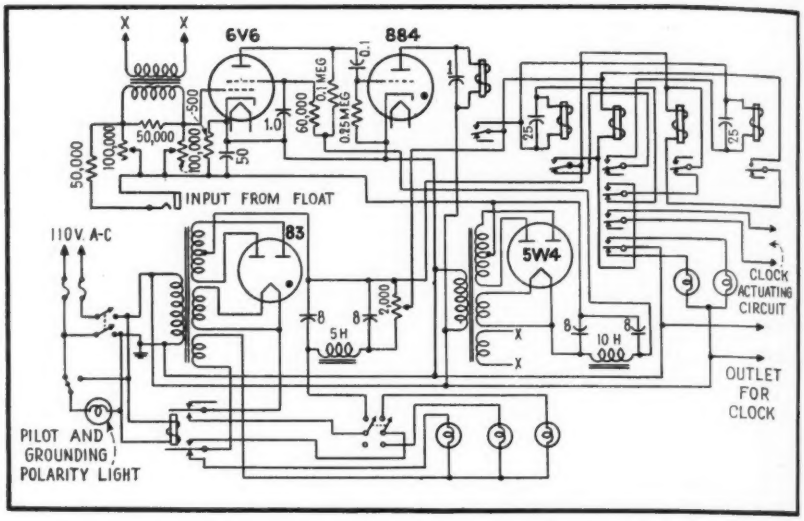


FIG. 23—Electronic circuit used to time the passage of a metallic float down a model waterway. The float contacts a wire as it passes the starting point and a clock is started. It then contacts another wire farther downstream and the clock is stopped

Electronic devices are meeting the instrumentation requirements of the Experiment Station by means of the apparatus described above and in many other ways. Much work has been done in connection with model photography, including timed flashes for velocity measurements by means of timed floats, and in the timing of photographic processes. Salt-water studies have required the development of conductivity apparatus, and a soil moisture content and temperature investigation has required other special equipment. New developments and applications are continuously under way in the Electrical Measurements Laboratory.

The Waterways Experiment Station operates under the supervision of the President, Mississippi River Commission, which is a direct agency of the Office of the Chief of Engineers. Brigadier General Max C. Tyler is President, Mississippi River Commission, while activities of the Experiment Station are directed by Gerard H. Matthes, Head Engineer.

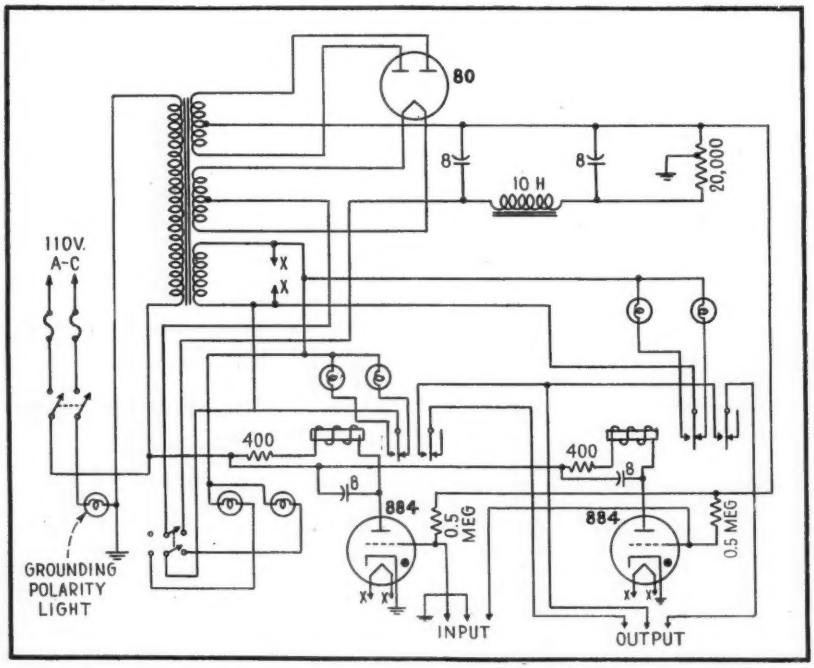


FIG. 22—Thyratron booster circuit employed in studies of tidal cycles. It avoids irregularities of operation formerly caused by corrosion of contacts mounted on floating supports and insures proper control relay operation

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INTERFERENCE IN F-M RECEIVERS

Review of equations covering interference-suppressing ability when desired and undesired signals have the same average frequency, with experimental verification by measurements on a representative commercial receiver

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Collingswood, N. J.

THERE has been developed a theory by Reich[1], Pollack[2], and several others concerning the ratio of interference to desired signal in the audio output of an idealized frequency-modulation receiver for known ratios of interfering to desired input signals. The object of this investigation was to determine whether or not an average commercial frequency-modulation receiver adheres to this theory regarding interference.

The type of interference which was studied and applied in measuring the suppression ability of the receiver under test was that which results from two signals having the same average frequency, one being considered as the desired signal and the other as an interfering signal. The conditions chosen represent an interference problem at its worst.

Theory of Single-Channel Interference

For convenience, consider the desired signal to be of unit amplitude, and the interfering signal to be of amplitude a. It is assumed that if a were comparable to "unity," the interference would be so great that no one would attempt to listen to the desired signal. Consequently, this case has little practical interest. However, when the desired signal is at a modulation lull, the interfering signal, even though relatively small in magnitude, produces an undesirable psychological effect, since it can now be heard together with the desired audio output. It is under these general conditions that the interference suppression of a commercial receiver was studied.

A term which occurs quite frequently in the analysis of single-channel interference is instantaneous frequency. Assuming a voltage of the form $e = A \cos \phi$, a customary and suitable definition of instantaneous frequency is $\omega = d\phi/dt$, where ω is the instantaneous angular frequency and $d\phi/dt$ represents the rate of change of the angular displacement with respect to time.[3] It is this definition that will be used.

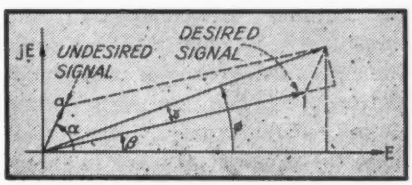

FIG. 1—Vector diagram for desired and undesired f-m signals, both having the same frequency

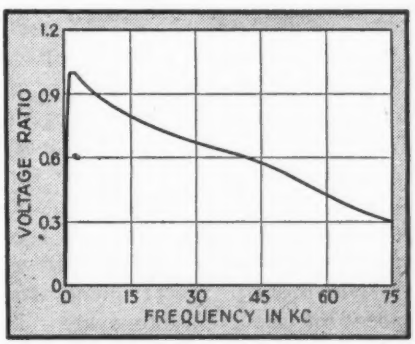

FIG. 2—Frequency response of output system into which audio system of f-m receiver was fed for visual indication of interference wave form

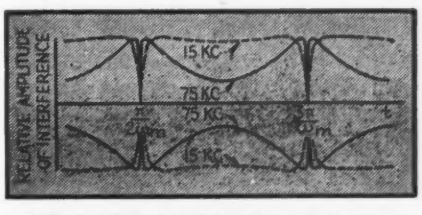

FIG. 3—Calculated interference pattern envelopes for deviations of 15 and 75 kc

The desired signal is not modulated, the condition of a modulation lull being assumed; only the carrier is present. The undesired signal is frequency-modulated with a frequency deviation of $\pm\overline{\Delta\omega}$ and at a modulation frequency of ω_m which is much less than the carrier frequency.

Referring to Fig. 1, the desired and undesired signals at some instant of time are respectively 1 cos β and a cos α. The following expressions may be written

$$\frac{d\beta}{dt} = \omega_0 = \text{constant carrier frequency} \quad (1)$$

$$\beta = \int \omega_0 \, dt = \omega_0 t + \theta \quad (2)$$

$$\frac{d\alpha}{dt} = \omega'(t) = \omega_0 + \overline{\Delta\omega} \cos(\omega_m t) \quad (3)$$

which represents the frequency variations of a frequency-modulated signal. Then

$$\alpha = \int \omega'(t)dt = \left[\omega_0 t + \frac{\overline{\Delta\omega}}{\omega_m} \sin(\omega_m t + \theta)\right] \quad (4)$$

The output of a frequency-modulation receiver should be proportional to the instantaneous frequency of the input signal. In the present case, the instantaneous frequency resulting from the superposition of two input signals is to be determined. Referring to Fig. 1 again, the instantaneous frequency of the resultant signal is seen to be $\omega = d\phi/dt$. The problem, therefore,

not an audio amplifier. The audio output of the receiver was fed into the output system, which consisted of the following units given in the order of connection to the receiver: (1) a calibrated voltage-dividing network; (2) a high-gain voltage amplifier; (3) a high-pass filter circuit; (4) an oscilloscope.

The voltage-dividing network was used to produce an equal deflection on the oscilloscope screen for the cases of interference and desired signal respectively in the audio output of the receiver. It was thus possible to determine N/S for various prescribed input conditions. Because of the small magnitude of the interference voltage it was necessary to provide the high-gain voltage amplifier. Also, because of the small magnitude of the interference voltage, hum pickup of supply power frequencies and harmonics thereof became objectionable. The high-pass filter was inserted to eliminate this trouble. The oscilloscope was used to give a visual indication of the interference wave form and also as an indicator of its peak amplitude.

The over-all frequency response of the output system is given in Fig. 2. This includes the amplifying circuits of the oscilloscope. The effect of the filter circuit in cutting off the lower frequencies is evident. The linear frequency scale was used to give direct comparison with the cathode-ray oscilloscope patterns.

For the particular receiver tested, the over-all time constant, corresponding to that which occurs in the analysis, was measured and found to be 80 microseconds.

In calculating the envelope of the interference pattern so that it may be compared with the experimental pattern as seen on the screen of the oscilloscope, the attenuation effect of the output system with respect to frequency is just as important as the attenuating effect of the deemphasis circuit in the receiver. Consequently, the envelope of the calculated interference pattern is proportional to the magnitude of Eq. (9) multiplied by the frequency response curve of the output system.

Since the interference frequency has a maximum value equal to the frequency deviation, the shape of the interference pattern envelope depends on the deviation. This envelope has been plotted for the two representative deviations of 75 and 15 kc and for the measured time constant of 80 microseconds in both cases. These plots are given in Fig. 3.

Photographs of the experimentally obtained patterns for the same two deviations and time constant are shown in Fig. 4. In these photographs, it is possible to see the actual variation in the interference frequency. This variation is sinusoidal and is represented by the changing density of the lines crossing the horizontal axis. It can be seen that the portion of the pattern having the greater density of lines is of a lower amplitude. This is consistent with the attenuating effects of the output system and the deemphasis circuit. To correlate the effects of the various attenuating factors on the interference pattern envelope, Fig. 5 is included.

Conclusions

The quantitative results are given in Fig. 6. Before the significance of the results is discussed, it might be well to elaborate on how the theoretical line, which indicates N/S as a function of a, is obtained. The theoretical line is obtained from Eq. (10) using the measured value of time constant equal to 80 microseconds. The value of interference frequency used was obtained graphically from the calculated interference pattern envelope for the 75-kc deviation. The interference frequency corresponding to the maximum point in the envelope was used in the calculations.

The measured and theoretical results deviate somewhat for increasing values of a. This is justified by the basic assumption that a is considered to be much less than unity.

The variations in measured results for different values of desired input signal are probably attributable to a slight error in the decade attenuation box on the f-m signal generator used. For small values of a, where the theoretical line is more accurate, these variations are of little importance.

In conclusion, the significant result of this investigation is that calculations relative to interference made on the basis of an idealized frequency-modulation receiver have been applicable to a representative commercial receiver.

This article is based on a bachelor's thesis submitted to the Department of Electrical Engineering of Massachusetts Institute of Technology. The author wishes to acknowledge the generous assistance of Professor L. B. Arguimbau, who supervised the thesis.

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(2) Pollack, Dale, M.I.T. E.E. Doctorate Thesis, 1940.
(3) Brainard, J. G., "Ultra-High Frequency Techniques," D. Van Nostrand, New York, 1942, p. 233.

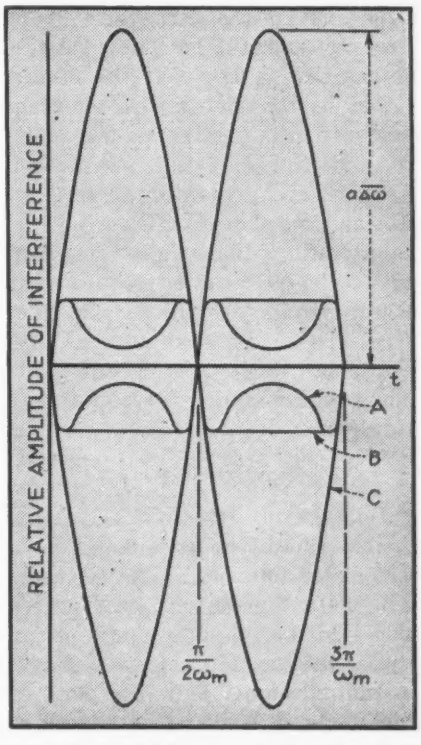

FIG. 5—Interference pattern envelopes for various attenuating factors. A—deemphasis circuit and output system; B—deemphasis circuit alone; C—theoretical envelope for no attenuating factors

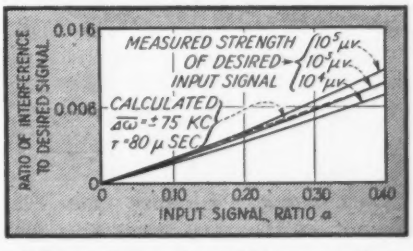

FIG. 6—Ratio of interfering signal to desired signal in the audio output of a representative f-m receiver, plotted as a function of the input signal ratio

is to solve for the value of ω.

It can be seen by inspection that $\phi = \beta + \gamma$. Now by simple trigonometric relationships we can write

$$\gamma = \tan^{-1} \frac{a \sin (\alpha - \beta)}{1 + a \cos (\alpha - \beta)} \qquad (5)$$

or, since a is much less than unity

$$\gamma \cong a \sin (\alpha - \beta) = a \sin \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (6)$$

Then

$$\phi = \beta + a \sin \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (7)$$

By definition

$$\omega = \frac{d\phi}{dt} = \omega_0 + [a\ \overline{\Delta\omega} \cos (\omega_m t)] \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (8)$$

where

- ω = resultant instantaneous angular frequency of input signals
- a = magnitude of undesired signal, equal to the ratio of interfering to desired input signals since the desired signal is of unit amplitude
- $\overline{\Delta\omega}$ = maximum angular frequency deviation of interfering signal
- ω_m = angular frequency of modulation of interfering signal
- t = time in seconds

Analysis of Discriminator Output

The resultant instantaneous angular frequency as given by Eq. (8) is seen to be composed of both a constant and a varying term. In a frequency-modulation receiver, the output of the discriminator is proportional to the variations in the instantaneous angular frequency. Consequently, the varying term of Eq. (8) is important in this analysis. It is equivalent to a sinusoidal variation with magnitude $[a\ \overline{\Delta\omega} \cos (\omega_m t)]$ and frequency $d/dt\ [(\overline{\Delta\omega}/\omega_m) \sin (\omega_m t)] = \overline{\Delta\omega} \cos (\omega_m t)$, with both the magnitude and the frequency varying sinusoidally with time. This varying frequency will be defined as the interference frequency and will be denoted by the symbol f_{int}. Thus, $f_{int} = [\Delta\omega \cos (\omega_m t)]/2\pi$.

Considering Eq. (8) once again, the resultant instantaneous angular frequency varies sinusoidally in magnitude about the mean carrier frequency ω_0. These variations are from ω_0 to $\omega_0 + a\ \overline{\Delta\omega}$ and back to ω_0 for half a period of the modulating wave. At any particular instant of time, deviation of the resultant instantaneous angular frequency is occurring at a definite frequency which is the interference frequency. Thus we have a frequency (the resultant instantaneous angular frequency) varying sinusoidally in magnitude at some other frequency (the angular modulation frequency). Also, when viewed at successive instants of time, these variations are in themselves varying sinusoidally at still another frequency, the interference frequency.

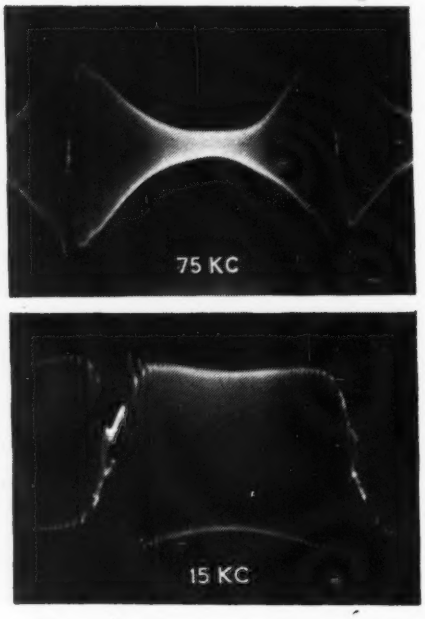

FIG. 4—Oscilloscope patterns obtained under same conditions as represented by Fig. 3

Allowances for Deemphasis

The results thus far have given us, theoretically, the wave form of the interference in the output of a frequency-modulation receiver, since in this type of receiver the audio output is proportional to the variations in instantaneous frequency as given in Eq. (8). However, in practice the frequency response of the receiving system is not flat. This is due to the frequency limitations of the audio system and to the standard deemphasis circuit placed at the output of the discriminator to restore the modulation to what it was before standard RMA preemphasis at the transmitter. This preemphasis of the higher-frequency components is proportional to $\sqrt{1 + (\tau\omega_1)^2}$, where τ is the standard 100-microsecond time constant and ω_1 is the angular frequency. The reciprocal of this proportionality factor is effected in the receiver by the deemphasis circuit. Consequently, the interference in the audio output is actually proportional to

$$\frac{[a\ \overline{\Delta\omega} \cos (\omega_m t)]}{\sqrt{1 + (\tau\omega_1)^2}} \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] = \frac{a\ 2\pi f_{int}}{\sqrt{1 + (\tau\ 2\pi f_{int})^2}} \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (9)$$

The ratio of interference to desired signal in the output of the receiver as considered in this analysis is N/S, where N is peak amplitude of interference in audio output of f-m receiver due to superposition of a small, undesired, frequency-modulated signal on an unmodulated desired signal, both signals being of the same average frequency, and S is peak amplitude of the desired signal alone, frequency-modulated, in audio output of f-m receiver.

The problem is to determine N/S for various ratios of input signals. The ratio of input signals is given by a since the desired signal is considered to be of unit amplitude. In this analysis, the standard maximum frequency deviation of ±75 kc is assumed to correspond to the full permissible range of a modulating signal at the input of the system. It follows that the fractional utilization of this full range by the interfering signal in the audio output is

$$\frac{a\ 2\pi f_{int}}{2\pi \times 75{,}000 \sqrt{1 + (\tau\ 2\pi f_{int})^2}}$$

Thus the ratio of interference to desired signal in the output may be written as

$$\frac{N}{S} = \frac{a f_{int}}{75{,}000 \sqrt{1 + (\tau\ 2\pi f_{int})^2}} \qquad (10)$$

or, if $(\tau\ 2\pi\ f_{int})^2$ is much larger than unity, the above expression becomes

$$\frac{N}{S} = \frac{a}{2\pi \times 75{,}000\tau} = \frac{a}{\tau\ \Delta\omega} \qquad (11)$$

For $\tau = 100$ μsec, this reduces to $N/S = a/47$.

Practical Considerations

For input signal sources two signal generators were employed, one of which could be frequency-modulated. These were connected to the input terminals of the commercial frequency-modulation receiver under test. This particular receiver included a deemphasis circuit but

Operation

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that the wave shape and peak-to-peak voltage are unchanged, but that the output wave is all below zero or has been restored negatively in that the top of the wave is at zero.

This action is known as negative restoration. If we had taken an a-c square-wave input varying from −50 volts to +50 volts, we would find that our output would also be negatively restored, varying from zero to −100 volts. The difference in operation is that the capacitor charges to 50 volts instead of 100 volts.

The circuit behavior depends upon two facts: first, that the capacitor charged rapidly during the conduction period of the tube; second, that it discharged slowly during its discharging period. Thus the conducting or charging time constant must be very short in comparison with the time for half a cycle, and the non-conducting or discharging time constant must be very long with respect to the time for half a cycle. Under these conditions restoration is completed after one cycle.

Triode Circuit

Using the same circuit, let us substitute a triode for the diode so that the triode grid replaces the plate of the diode and the triode cathode replaces the cathode of the diode, as shown in Fig. 2. Because the grid and cathode of the triode act like a diode, the resulting wave shape between grid and cathode will be the same as obtained before, if we assume that the grid-to-cathode resistance during grid current flow is about 1000 ohms, as was true of the diode. Because this wave varies from zero to 100 volts negative and has equal half cycles, we can consider it as an a-c wave of 50 volts above and below zero, being applied on a bias of −50 volts. In other words, we have developed a grid bias of −50 volts by means of the d-c restorer.

Positive Restorer

Let us examine the circuit of Fig. 3, which differs from the circuit in Fig. 1 in that the diode has been reversed and we are now using a balanced square-wave. During the first half cycle the +50 volts will appear across the tube, making the cathode positive with respect to the plate and resulting in the tube not conducting. The capacitor charging through the one-megohm resistor will charge very little so the wave shapes for the first half cycle are as indicated in Fig. 3(c) and 3(d).

When the voltage reverses in the second half of the first cycle, approximately −50 volts will appear instantaneously across the tube, making the cathode negative with respect to the plate and causing the tube to conduct, quickly charging the capacitor. The voltage across the resistor and capacitor is as shown for the second half of the first cycle in Fig. 3.

At the first half of the second cycle, the generator is delivering +50 volts and the capacitor is charged to 50 volts in a polarity as indicated in Fig. 3. Because the generator and capacitor voltage are additive, the voltage across the resistor will instantaneously be +100 volts. The capacitor will not discharge very much through the long time-constant circuit. Thus the voltage across the capacitor will remain at almost −50 volts and the voltage across the tube will remain at practically +100 volts as shown in Fig. 3(d). During the second half of the second cycle, the generator and capacitor voltage will be in opposition and the voltage across the tube will be the slight difference between the two. The capacitor will again quickly charge to −50 volts through the tube. The wave has been restored in the positive direction so that the lowest part of the wave is at zero and the rest above the zero axis. This circuit is known as a positive d-c restorer.

The circuit in Fig. 4(a) will produce positive restoration above the applied negative potential, as at Fig. 4(c). In this manner reference levels other than zero can be obtained.

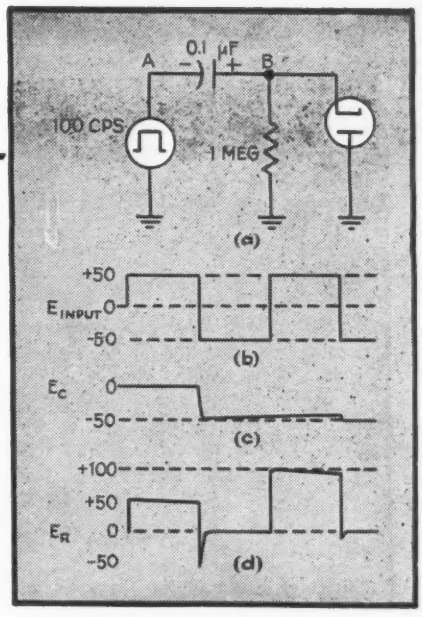

FIG. 3—Positive restorer diode circuit and wave shapes indicate how restoration bias is developed

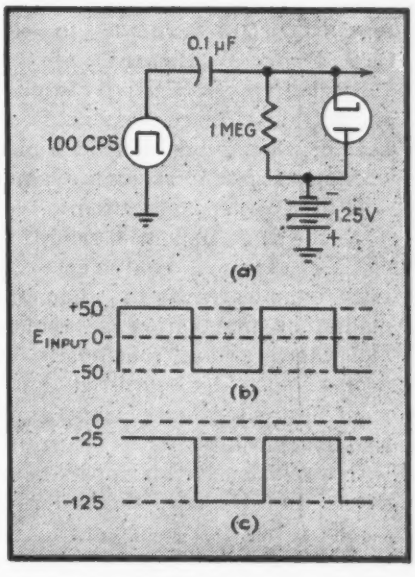

FIG. 4-(a) Biased negative restoration circuit, (b) input wave, and (c) output wave after equilibrium is reached

Restorer-Circuit

Qualitative explanation of the operation of the direct-current restorer circuit used in television receivers and related instruments to maintain constant brightness. The circuit shifts all incoming signals to the same direct voltage reference level

THE D-C RESTORER CIRCUIT makes the voltage applied to the grid of a tube start from a predetermined level, usually the cut-off potential of the tube. In television, this circuit alters the bias level of the tube so that signals to be reproduced on the cathode-ray tube are restored to the same relative intensities as those at the studio.

Let us consider a direct-current restorer circuit with values as indicated in Fig. 1(a). We have a square-wave generator of zero internal impedance, delivering an input voltage that varies from zero to + 100 volts at a frequency of 100 cycles per second as shown in Fig. 1(b). We shall also assume that the diode has about 1000 ohms of resistance during conduction.

Negative Restorer

During the first half cycle, the generator can be considered as a battery of 100 volts. The 100 volts will instantaneously appear across the resistor because the voltage across the capacitor cannot change instantaneously. Thus the plate of the diode is positive with respect to the cathode and the diode will conduct. The 1000 ohms of the conducting diode in parallel with the one-megohm resistor gives a resultant resistance of about 1000 ohms. The 0.1-μf capacitor charges through 1000 ohms resistance. The time constant of this charging circuit is 100 microseconds.

The time during which the capacitor can charge is the time during which the 100 volts is applied, or the time for a half cycle of the square wave. Because the frequency of the square wave is 100 cycles per second, the time for half a cycle is 5000 microseconds or 50 times the time constant of the R-C charging circuit. Since at the end of a period equal to six time constants we can consider the capacitor fully charged for all practical purposes, we see that the voltage E_c taken from A to B across the capacitor follows the curve indicated in Fig. 1(c). The voltage across the resistor or tube is the applied voltage less the voltage across the capacitor at each instant of time, as indicated in the first half cycle of the Fig. 1 (d).

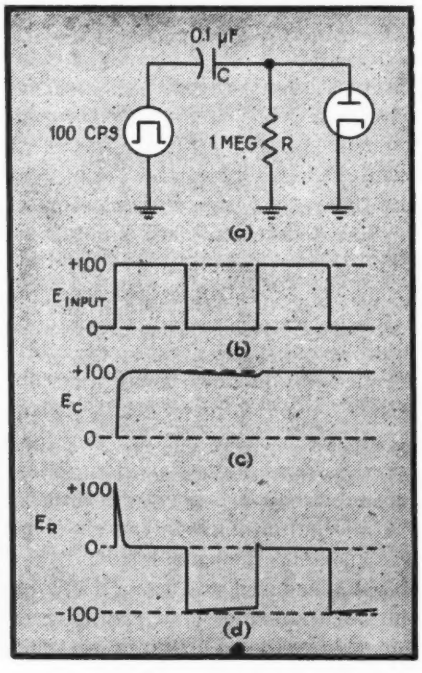

FIG. 1—Diode circuit for negative restoration and voltage wave shapes across various circuit elements

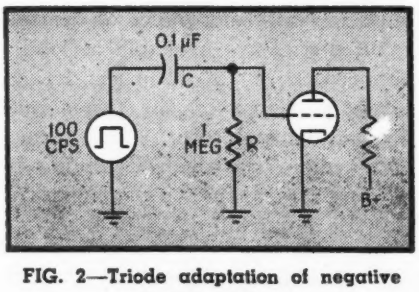

FIG. 2—Triode adaptation of negative restorer circuit

Capacitor Discharge

Because the input voltage from the generator is zero during the next half cycle and can be considered as a short circuit, the capacitor discharges through the one-megohm resistance, the full 100 volts appearing instantaneously across the resistor. The plate of the diode is now negative with respect to the cathode and the diode does not conduct. Thus the capacitor must discharge through the one-megohm resistor, giving a discharge time constant of 100,000 microseconds.

The capacitor will discharge only during the half cycle during which the generator is zero for a time of 5000 microseconds, thus the time available for discharge is 1/20 of a time constant of the discharge circuit. With this amount of time available, the capacitor will discharge a very small amount and the voltage from A to B will be, for the second half cycle, as shown in Fig. 1(c). The voltage across the resistor will be as shown in the second half cycle of Fig. 1(d).

During the first half of the second cycle, we again have +100 volts applied. The capacitor has a charge of almost 100 volts, just a slight positive voltage appears across the tube (E applied minus E_c). This small voltage will cause the tube to conduct, charging the capacitor quickly back up to 100 volts. The voltage across the tube will subsequently drop to zero. The voltage across the capacitor and resistor for this half cycle is shown in Fig. 1(c) and 1(d) (E_c and E_R for the first half of the second cycle).

If we compare the output voltage with the input voltage, we see

VIBRATION C E

Aircraft installation of this typical Collins transmitter requires some means of stopping vibration and shock before it reaches the equipment. Mounting gear of the type shown here is described in the text

DEVELOPMENT TRENDS in electronic equipment are all toward greater sensitivity, lighter weight, and more compactness—each of which tends to make a piece of apparatus increasingly vulnerable to shock and vibration.

At the same time, field conditions for electronic equipment—war uses, applications in industrial plants, or installation in vehicles and carriers, are continually exposing this highly-evolved equipment to greater adversity by vibration and shock.

One solution to this apparent impasse, and perhaps the only one which gives full consideration to the two opposing factors, is the use of devices which, in effect, cut the sensitive equipment loose from the vibrating platform.

Principles and Terminology

In the early stages of the vibration-control art, the typical way of combatting vibration involved the incorporation of structural materials of various kinds.

The designer called upon cork, felt, sponge rubber, or springs to solve his problems without much recourse to anything more than rule-of-thumb specifications. Examples include the early carbon microphone suspension which did what was necessary but with only a small resemblance to the type of mounting that would be considered good design today.

TABLE I—VIBRATION INSULATION

Insulation Ratio	Percent Insulation	Result
10.0	98.9	Excellent
4.0	93.3	Very good
3.0	87.5	Good
2.5	81.1	Fair
2.0	66.7	Useful
1.5	20.0	Poor
1.4	0.0	None
1.0	Amplification	Resonance

A classic point of departure in considering the principles of vibration control is the concept of a birdcage hanging from a coiled-wire spring. If such a load is pulled downward and then released, it will vibrate at its natural frequency. Its static deflection is the distance the spring elongated when the cage was hung. A forced frequency would be introduced if the top of the spring were hand-held and shaken up and down at a constant rate. The faster this rate, the less tendency there is for the cage to respond, but when the natural and forced-frequencies coincide, response reaches a maximum. In other words, if a frequency match is created, a condition of resonance occurs and the result is amplification of vibration and its attendant troubles. Effective vibration isolation depends on the creation of a mismatch in frequency.

Natural frequency bears the linear relation to static deflection shown in Fig. 1. Insulation ratio is another concept sometimes used and arrived at by dividing forced frequency by natural frequency. The ratio is an indication of the effectiveness of a mounting system as indicated in Table I. Figure 2 gives the relationship between insulation ratio and vibration absorption—including its negative counterpart, amplification. Obviously, effectiveness of vibration control rises with the insulation ratio. At an insulation ratio of $\sqrt{2}$, vibration absorption is zero, and such a system would provide no control.

As pointed out by Connon*, the

* Connon, J. A., Vibration Insulation and Structural Rubber, AIEE Tech. Paper 45-76.

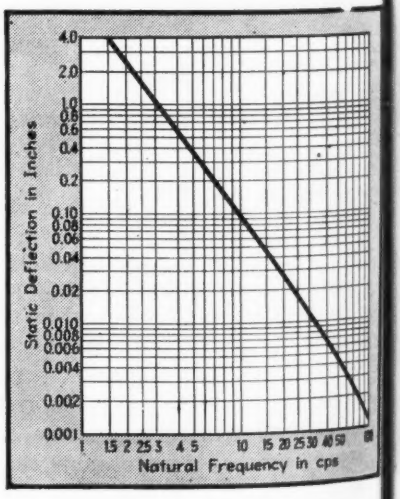

FIG. 1—Resonance can be determined from this linear relation between static deflection and natural frequency in a spring system. A mismatch is desirable to avoid resonance and amplification of destructive vibration

CONTROL for Electronic Products

A review of the many types of specialized units designed to provide isolation and control of destructive vibration and shock. Also included are notes on principles involved in the design of mountings

vibratory forces at a given point in a system occur in several directions at different frequencies and with different amplitudes and may combine translatory and rotary components. Vibration in each direction must be considered with relation to the natural frequency of the resilient suspension in that direction. Figure 3 is a typical shipboard record which shows the different character of the fore-and-aft, the vertical, and the athwartship components.

Source and Cure

By and large, the complicating frequencies relate to those of rotating or reciprocating mechanisms elsewhere in the equipment or its supports. In generalizing on the things which can be done to resolve

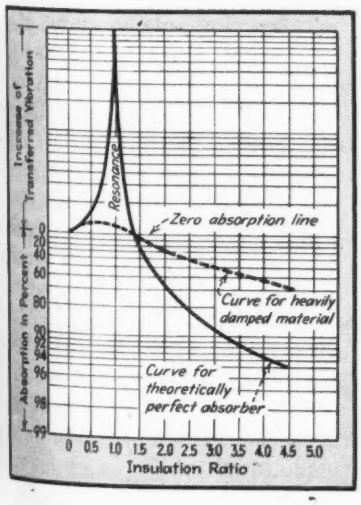
Increase of Transferred Vibration
Absorption in Percent
Resonance
Zero absorption line
Curve for heavily damped material
Curve for theoretically perfect absorber
0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Insulation Ratio

FIG. 2—Insulation ratio is an arbitrary index obtained by dividing forced frequency by natural frequency. Plotted against percent absorption, it shows critical points at 1, or resonance, and 1.4, where absorption begins

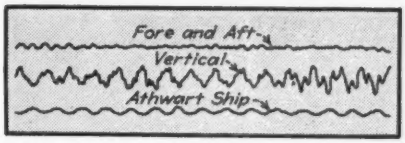

FIG. 3—(above) Components of vibration in a shipboard installation

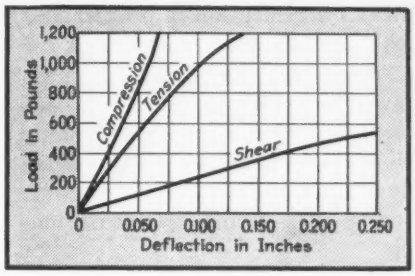

FIG. 5—(right) Shear deflections permit a low natural frequency

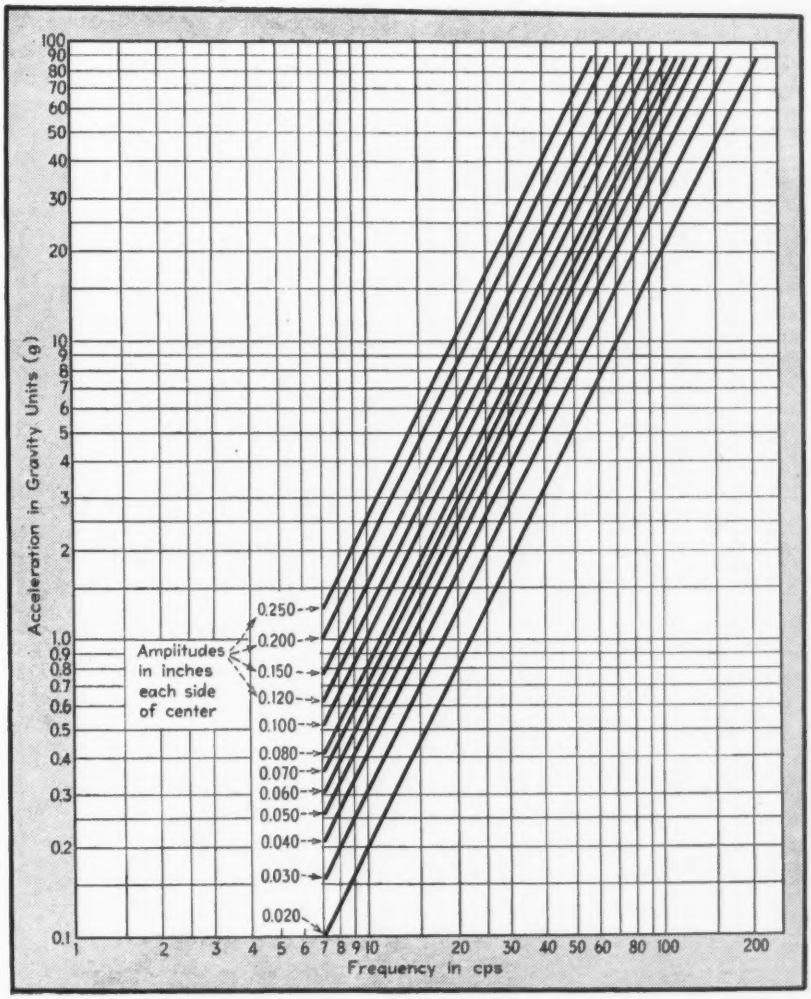

FIG. 4—Family of curves relate acceleration, frequency, and amplitude in accord with the general equation for maximum acceleration of a particle moving in simple harmonic motion

these factors, it is commonly recommended that mounting units be used which have the greatest deflection consistent with stability; that the mounting have a highest natural frequency sufficiently below the lowest expected forced-frequency to give adequate insulation; and that the softest axis of the mounting be installed parallel to the direction of the greatest induced disturbance.

Harmonic Motion

Figure 4 shows the relationship between acceleration in g units and frequency in cycles per second for a series of amplitudes. These curves were derived by W. A. Dickinson, Sylvania Electric Products, from the general equation for maximum acceleration of a particle moving with simple harmonic motion

$$a_g = \frac{(2\pi f)^2 x}{g} = 0.102 f^2 x$$

where a_g is acceleration in gravitational units, f is frequency in cps, x is amplitude in inches, and g is acceleration due to gravity in inches per second. Vibration problems are generally more complex than simple harmonic motion.

The foregoing notes on theoretical considerations apply to spring systems generally where the elastic member deflects according to Hooke's Law, which states that within the elastic limit of any body, there is a constant ratio between stress and strain produced.

Among fabricated components, rubber mountings are available in a wide range of styles. They can be further classified by whether the rubber is utilized in compression, tension, shear, torsion, or flexure. A large number of mountings are of the shear type, because the same load ordinarily gives a greater deflection in shear than it does in a compression or tension system, which are the other two principal modes of usage. This is demonstrated in Fig. 5.

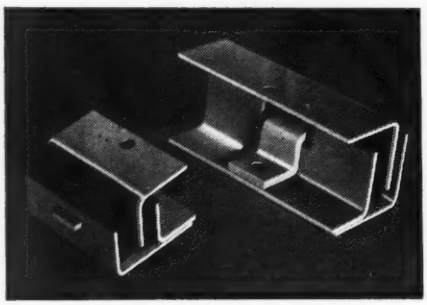

FIG. 7—Three-angle-type mounting includes a locking bar projecting through all parts to hold them together in case of damage to the rubber

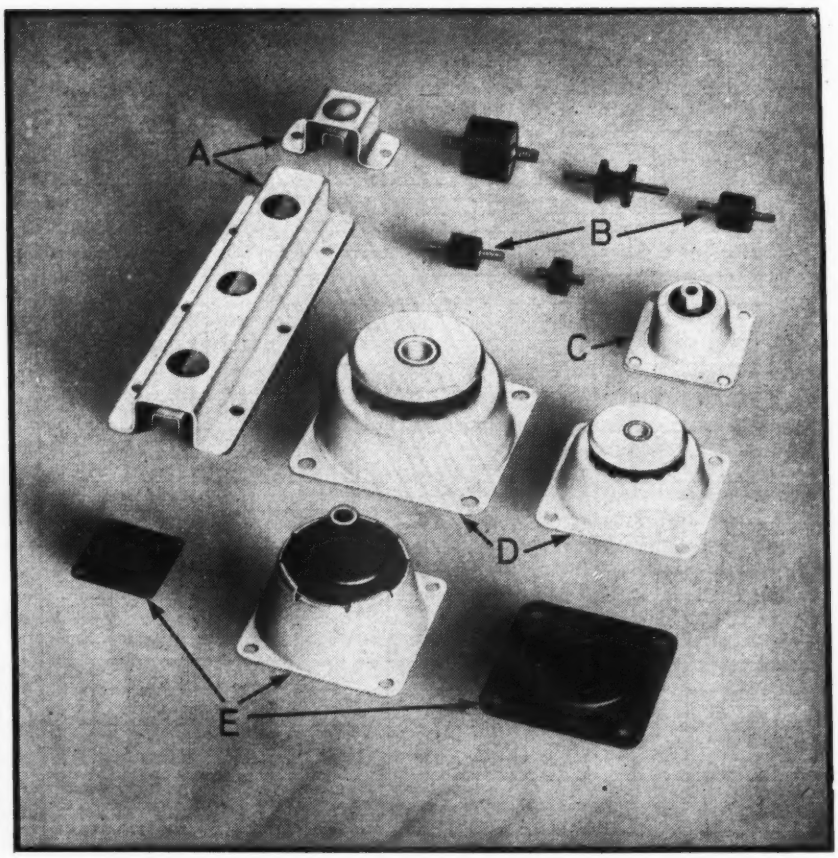

FIG. 6—Several types of rubber mountings made by U. S. Rubber Co. Type (A) are channel-shear mountings; (B) cylindrical compression or shear; (C) safety-type cylindrical; (D) flexure-compression cups; and (E) flexure

Specialized Components

Among the designs of United States Rubber Co. are channel-type mountings illustrated in Fig. 6(A). These units are used to absorb vibration in any direction which stresses the rubber in shear. They are so designed that the load is supported on the inner channels—connections being made by a stud—which provides a safety feature. If the rubber bond fails because of fire or accident the support is still contained within the outer channel and the mounted apparatus cannot get away even when suspended from above.

In this style, two sizes are available with overall widths of 2 and 4¼ in. Each of the two widths is available in a number of different lengths. The smaller is used for applications from a minimum load of 4 lb, at 50 cps (giving 81 percent vibration absorption), to 95 lb maximum at 25 cps. Range of the larger size is 24 lb minimum and 33 cps (81 percent vibration absorption) to 420 lb maximum at 16 cps. In the smaller size, the lengths available are 1, 2, 3 and 6 inches, while in the larger size they run 1.5, 3, 5, 7 and 9. Vibration control at frequencies higher than those noted are better than 81 percent. Loads are given for each individual mounting. The total would be divided among the number of units used to support a given piece of gear.

Figure 7 shows another available type of mounting which utilizes rubber stressed in shear. This one is called a three-angle type and is classified functionally as a shear sandwich. A safety feature is provided with this unit in the form of a bar which projects through a lateral slot to lock the three angles against disintegration. It is supplied in two sizes—4⅜ in. wide by 4⅛ in. long, and 4⅞ in. wide by 8½

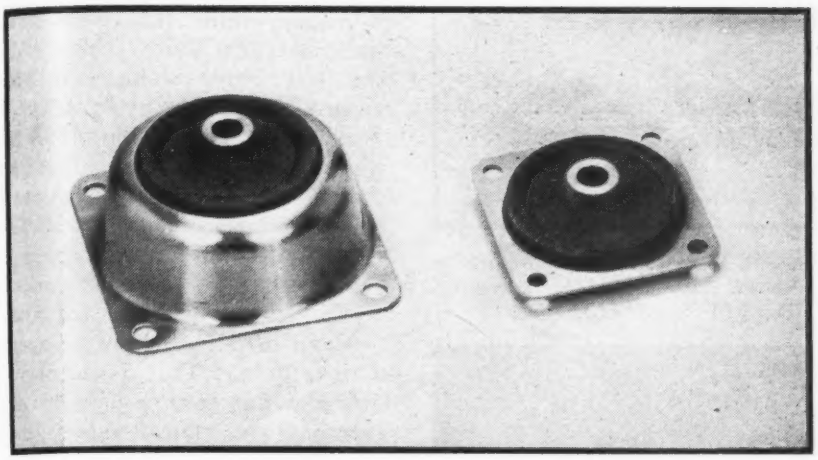

FIG. 8—Bonded cup-and-plate mountings of these types are offered by Lord Mfg. Co. Rubber is chemically joined to outer metal supports

in. long. Load ratings range from 37 lb minimum at 33 cps to 900 lb maximum at 14 cps.

Cylindrical mountings are available in a variety of configurations. As shown in Fig. 6(B) they consist of rubber members bonded on each end to mounting studs. Circular types are listed in diameters of $\frac{7}{16}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{3}{8}$, $2\frac{3}{4}$ and 3. Square styles are made in the smaller sizes. Depending upon their positional arrangement, these units can be stressed either in shear or in compression. Their load limits range from 0.5 lb minimum at 50 cps to 700 lb maximum at 21 cps.

Figure 6 (C) is a special type mounting having a close characteristic relationship to the cylindrical units, but adding the safety feature of an enclosing cup. In this type the load range is 3 lb at 31 cps vertically and 15 cps horizontally, to 7 lb at 23 cps vertically and 13 cps horizontally.

Mountings indicated as Fig. 6(D) are classified as flexure-compression-cups. They give about the same spring rates horizontally as they do vertically. The load deflection curve on this type is smooth, without any discontinuity at the point where the bumper comes into play which makes them valuable for repeated shock loads where the mounting frequently strikes against its limiting bumper. Having a minimum load faculty of 6 lb at 55 cps, the two sizes illustrated cover the range to 20 lb at 31 cps.

For equal horizontal and vertical spring rates, another type has been developed utilizing the elastic member in flexure. This is shown in Fig. 6(E). Units in this family exhibit large deflections under light loads and make it feasible to control vibration of a relatively low frequency. At a minimum load of 1 lb, 81 percent vibration-control by the smallest size goes down to 31 cps, while the largest extends to 35 lb at 15 cps.

Mountings of a rectangular type are supplied in the following sizes: $1\frac{7}{8}$ by $5\frac{1}{4}$ in., $2\frac{1}{2}$ by $6\frac{3}{4}$ in., and $2\frac{1}{4}$ by 8. Load limits here range from 30 lb minimum in shear at 40 cps to 1,050 lb maximum in compression at 20 cps.

Other products of the company include special circular indicating-instrument mountings, compression cup mountings which are primarily designed to stop the transmission of noise through structures; multi-action units which are useful for absorbing vibration in one direction only and at the same time acting as guides to restrict movements in other directions; heavy duty shear sandwiches capable of carrying loads up to 3,000 lb; compression pads; rubber bumpers in various types and designs; square pads; and structural cellular rubber in slabs which can be used to support an entire section of a larger structure.

Specializing in shear type mountings, Lord Manufacturing Co. offers a line of tubular types which utilize rubber bonded to the adjacent inner and outer diameters of coaxial cylinders. These range from rated loads of 23 lb to 1450 lb and in length from $\frac{7}{8}$ in. to $5\frac{3}{4}$ in. They are divided into six sub-types, with rated deflections of 0.065, 0.068, 0.078, 0.092, 0.108, and 0.123 in.

Another standard line of the same company consists of a series of plate-type mountings as illustrated in Fig. 8 with a choice of square, diamond-shaped, round and cup-shaped metal holding-members. The lenticular rubber disk is bonded to the interior of the circular hole in the mounting member and the load is attached to a bolt through the central bushing. Here, maximum allowable loads range from 1 lb to 120 lb with 1-, $1\frac{1}{2}$- and 2-in. diameter rubber members and $1\frac{1}{4}$- to 3-in. overall dimensions. Normal

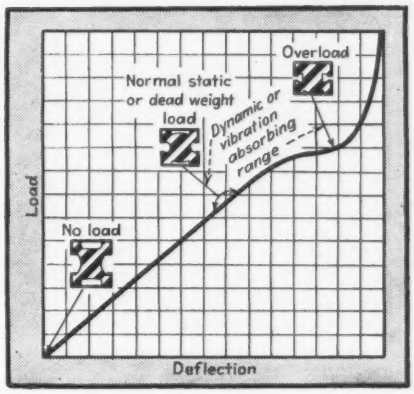

FIG. 9—Mountings with no-load cross-section as shown in lower diagram deform for increasing loads. Metal and rubber parts are held together without bonding. Rubber bar slips into metal channel from the end. The manufacturer is Hamilton Kent Mfg. Co.

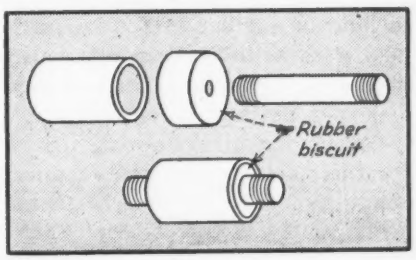

FIG. 10—Friction and pressure hold the three parts of this General Tire and Rubber Co. unit together. Radial, conical, and axial loads are accommodated

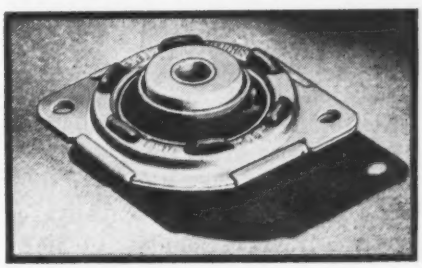

FIG. 11—In this non-bonded mounting by Harris Products Co. the outer support is crimped together with rubber lugs projecting through the metal. The central mounting hole is stabilized by a tube and retaining rings

which is engineered as an complete mounting-base subassembly. The manufacturer is Robinson Aviation Inc. Derived from early and effective aerial camera mounts, this unit operates on a crossed-axis principle, elaborated in Fig. 14. As shown in the diagram, primary cushions *P* absorb part of the initial vibration impulses about the axis *X*. Residual vibration is conducted along structural members to secondary cushions *S* mounted on axis *Y*. These absorb a large portion of the residual vibration, passing along through the supporting unit something ordinarily less than 5 percent of the amplitude of the original driving impulse. A typical vibration absorption curve as shown in Fig. 15 reveals that action is quite effective between 10 and 60 cps, which is the range used in many tests.

In the construction of these units eight special cushion blocks of low density rubber are assembled into the base, at points of minimum motion, where they act with optimum effectiveness. Each block has a top and bottom convex curvature, as revealed in Fig. 16(A), which disappears under load but assures even distribution of stress throughout the block. Figure 16(B) and 16(C) demonstrate compression and shear action of these blocks.

Combination Units

Special characteristics are designed into many of the heavier-duty units by combinations of steel springs, cork and rubber pads and even wood chocks. A multi-purpose type produced by the Korfund Co., Inc., suitable for the control of vibration in all directions, is illustrated in Fig. 17. It consists of a welded structural steel housing incorporating cold-rolled oil-tempered crucible-steel springs. The upper and lower members of the housing are held in a relative position against lateral movement by four resilient chocks.

Equipment to be isolated is fastened to the top plate by means of a bolt passing through the machine base and bearing on a plate which transfers the load to the springs visible inside the unit. Top and bottom plates of the housing are held in vertical relation to each other by bolts isolated with resilient washers.

Six sizes are offered to apply against a range of rated loads from 200 to 12,000 lb. Units weigh 7, 18, 32, 36, 49 and 60 lb. respectively, and have overall dimensions of 2½ by 6⅞; 5 by 6⅞; 5 by 9⅛; 7 by 9⅛; 7 by 11½ and 7 by 11½ in. on bases.

One of the latest types of vibration controls to be reported is one which is described as dissipating vibratory and shock forces in the form of heat. These absorbers consist of series of very thin sheets of metal, generally copper, placed one on top of the other and inclosed in an air-tight welded jacket. Mountings are used in compression, have no natural frequency, do not acquire a set in operation, and are unaffected by such conditions as moisture, oil, dust, and steam. Among sizes available are units as small as ¼ in. in diameter, standard types 4 by 4 by ¼ in., and others as large as 6 by 12 ft. by ¼ in.

Construction of these molecular vibration absorbers is based on a principle of discontinuities. Maximum reflectivity is produced by placing in contact two media whose difference in resistance to sound conduction is a maximum.

The manufacture of the unit involves locking to the surface of the metals a liquid film, and to this, a film of air. The liquid and air films are harder than steel and when used in connection with thin metal plates form an assembly possessing maximum discontinuities. The manufacturer, Chamberlain Laboratories, points out that, since such a large amount of work is done on a very small amount of air, its temperature rises above incandescence. Heat is instantaneously dissipated by radiation—F. H.

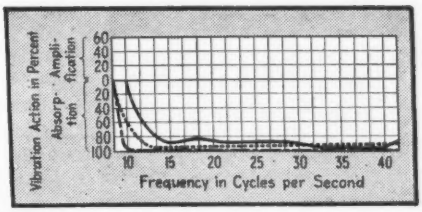

FIG. 15—Vibration absorption curve shows action of the mounting base illustrated in Fig. 13. The absorption range between 10 and 60 cps is widely used in tests. The solid line represents the vertical component; dotted, longitudinal; and dashed, lateral

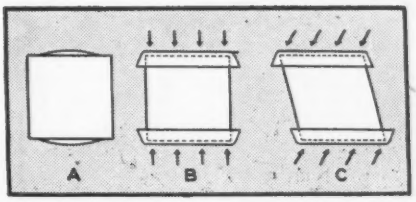

FIG. 16—Eight specially compounded rubber blocks of the conformation shown at (A) are represented by *P* and *S* in Fig. 14. The convex top and bottom flatten under load as shown in (B) and the blocks have uniformly distributed stresses

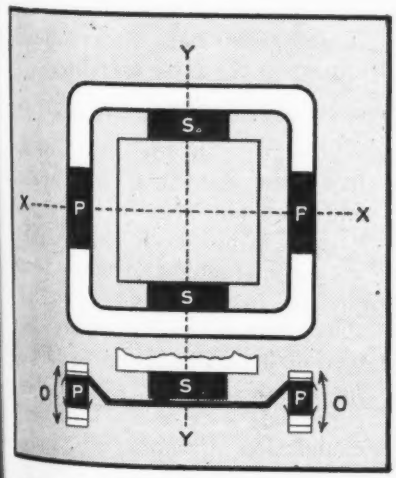

FIG. 14—Crossed-axis suspension is the principle used by the unit illustrated in Fig. 13. Primary cushions are indicated by P, secondary by S, respectively on the X and Y axes. Arcs O represent the limits of oscillation

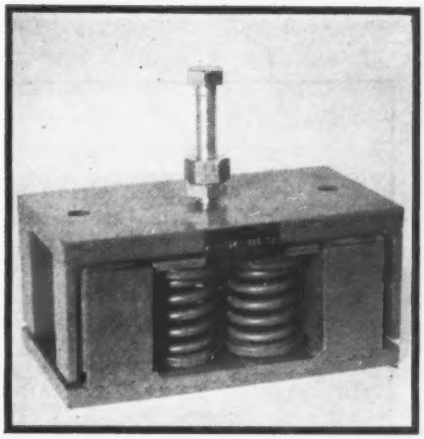

FIG. 17—Heavy-duty isolators are available in spring types like this from The Korfund Co., Inc. Bolt on top transfers the load of the mounted gear to the spring-borne plate immediately beneath

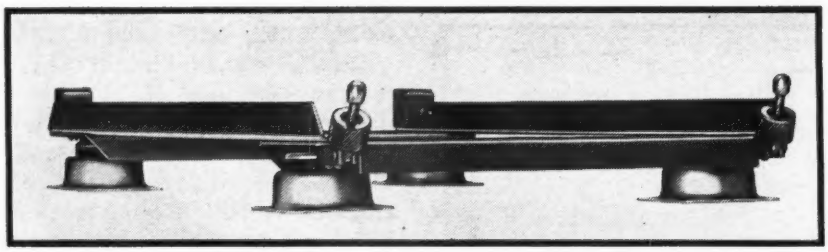

FIG. 12—Here the mounting base is a framework which exactly fits the piece of gear with which it is used. This type is shown suspended on four flexure-compression-cups (Fig. 6-D)

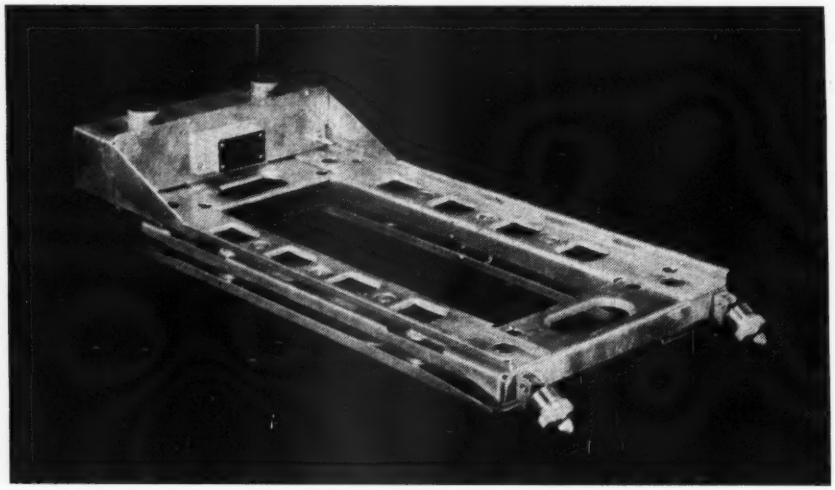

FIG. 13—Mounting base of another type is designed by Robinson Aviation, Inc. as a unit to fit equipment not only physically but from a vibration point of view as well. Also incorporated are plug-in electrical connections in unit at the rear called a doghouse

rating of this series ranges from 1 to 90 lb at $\frac{1}{16}$-in. deflection. (Frequencies can be read from Fig. 1.)

The full listing of the company includes a number of special products, such as indicating-instrument mountings and small specialized disk-type units.

Among mountings which depend for their action upon the chemical bonding of rubber and metal, those designed by B. F. Goodrich Co. show several variations from previously described types. A special style of shear sandwich $4\frac{1}{2}$ in. square is supplied with four mounting studs on each opposite face. It is suggested for a maximum load of 400 lb, at which it exhibits a shear deflection of 0.17 in. and where it is effective on a minimum disturbing frequency of 16 cps.

A channel-type mounting designed by this same company for shear action is similar to those previously described, except that the supporting channel is not surrounded by the base channel. This unit is $4\frac{1}{2}$ in. wide by $1\frac{3}{8}$ in. high and is rated at 50 lb per inch of length with a $\frac{3}{16}$ in. deflection and a minimum disturbing frequency of 16 cps. It is available in these lengths: 1, 2, 3, 6, 12, 24, 36 and 60 in.

Other available units include cylindrical, pedestal, offset shear sandwiches and compression-washer type mountings.

Not all rubber mountings depend on chemical bonding for their action. One type of mounting consists of a rubber x-bar member, as shown in Fig. 9, which slips into upper and lower metal containing elements. The supplier of this unit is the Hamilton Kent Mfg. Co., Kent, Ohio. One of the advantages attributed to this type of design is revealed by the load versus deflection curve shown. The dip in the upper third of the curve shows that deflection increases quite rapidly for small increments of load. This action at the overload point destroys any tendency for resonance and bounce.

Two types of mounts are offered for the handling of all types of vibration: one serves against horizontal, vertical, rotary, or inclined vibration, while the other is for purely vertical action. Units of the first type are cataloged in sizes from 6 by 9 in. to $9\frac{1}{2}$ by 15 in. in horizontal area by $2\frac{3}{16}$ to $2\frac{1}{2}$ in. high for a deadweight load ranging from 225 to 3,800 lb. In the vertical type, sizes range from 6 by 7 in. to $9\frac{1}{2}$ by 13 in. for the same load ranges.

Another method of securing rubber and metal is used by General Tire & Rubber Co. Their mountings gain adhesion by pressure and frictional resistance rather than molding and cementing. In a mounting of this type for radial, conical or axial loads, a separately molded rubber biscuit is contracted into a metal sleeve of smaller diameter as shown in Fig. 10. With a tapered mandrel, the inner diameter is expanded and the inner sleeve inserted.

In another type of non-bonded mounting offered by Harris Products Co., the rubber members are molded in separate parts. As shown in Fig. 11, outer rings are clamped together to secure rubber bosses into peripheral holes which lock the assembly. The inner boss is reinforced by two retainers and a center tube which maintains it in positive position. The units are supplied in square cups, square plates and diamond-shaped plates, and their load ratings, with 1/16-in. deflection, range from $\frac{1}{4}$ to 45 lb. Square bases are available in 1-11/16, 2-3/8, and 3 in., while the diamond-shaped units have lengths of 1.66, 2.32 and 2.97 in. All are supplied alternatively in steel and dural.

Subassembly Types

One of the current trends, particularly in the installation of electronic equipment in aircraft, is toward the use of mounting bases which exactly fit the piece of equipment to be installed and often incorporate sliding plug connections for electrical circuits. Examples of this are shown in Fig. 12 and 13. Fig. 12 is a base made up by combination of a set of four standard unit mountings of a type previously described with a metal subframe which fits under the equipment to be mounted. Fig. 13 shows a somewhat different type of unit

IMPEDANCES---Part III

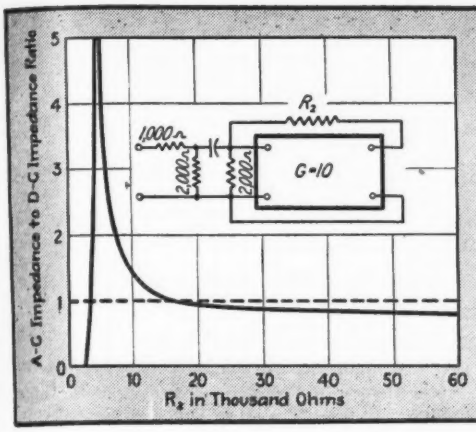

FIG. 22—Addition of negative resistance to diode detector improves the a-c to d-c impedance ratio

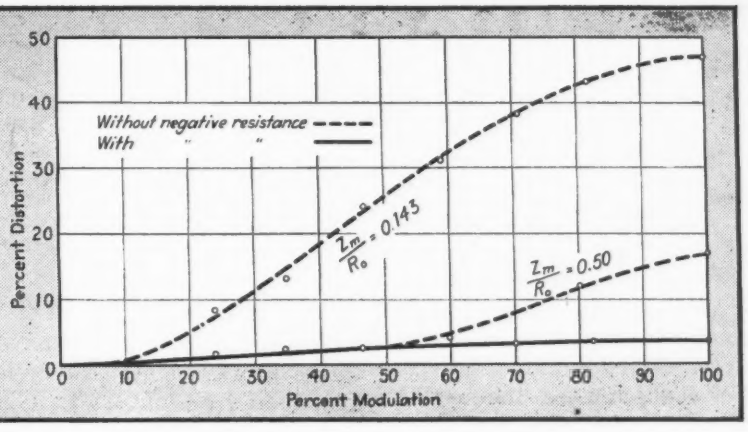

FIG. 23—Negative resistance added to a diode detector decreases distortion near 100 percent modulation

and will produce serious distortion. The manner in which the actual circuit shown here deviates from the ideal detector can be seen from a study of Fig. 21. The load circuit of the detector, due to various capacitors in the circuit, presents a lower impedance to the modulation frequency than it does to the direct current.

Let Z_m be the impedance offered by the diode load circuit to the modulation frequencies, and R_o the resistance offered by the same circuit to the direct current. While it is not readily obvious, Terman has shown that the maximum percentage of modulation m that the diode detector with a given load can rectify without distortion is

$$m = Z_m/R_o \qquad (57)$$

If the actual percentage of modulation of the applied radio frequency signal exceeds this value, the rectified output will be distorted. The nature of the distortion depends upon the nature of the ratio Z_m/R_o. If this is a reel constant, then the distortion will be in the nature of clipping of the negative peaks of the modulation frequency wave. If the load is such that the above ratio (commonly called the a-c to d-c ratio) has a phase angle, then the distortion will be clipping of the negative peaks at an angle with respect to the axis of the rectified wave. The wave-shape of the distortion is not important in this discussion.

The important fact is that the diode detector deviates from the ideal distortionless detector in two ways: (1) Modulation-frequency impedance does not equal the d-c resistance of the diode load. This produces clipping of the negative peaks if the actual degree of modulation exceeds Z_m/R_o. (2) Modulation-frequency impedance has a phase angle due to the fact that the shunting capacitor C acts as a partial short circuit at the higher modulation frequencies. This causes diagonal clipping of the negative peaks.

Improvement by Using Negative Resistance

The two effects which cause deviation of an actual diode-detector circuit from the ideal detector can be eliminated by the application of stabilized negative impedances.

The first of the two effects can be eliminated entirely by means of a negative resistance of the shunt type placed across the diode load at the output terminals.[15] The negative resistance may be so adjusted that its value is just equal to the shunting resistance which causes the difference between Z_m and R_o. This will make the ratio given by Eq. (57) just equal to unity which, in turn, means that 100 percent modulated signals can be rectified without distortion.

The second of these deviations from the ideal may be eliminated by using a negative capacitance supplied by an amplifier which has a uniform response up to the highest modulation frequency that it is intended to use, and yet which cuts off considerably below the carrier frequency. By means of this arrangement it is possible to make the net capacitance across the load, as far as modulation frequencies are concerned, just zero and there will be no diagonal clipping even for 100 percent modulated signals. And yet, because the amplifier cuts off at some intermediate frequency, the negative capacitance will be absent above cut-off and the net capacitance offered to radio frequencies across the load will be equal to something greater than C_1.

Measurements of Improved Detector

It is seen that by means of two kinds of negative impedances an ordinary diode detector can be made to approach the ideal one very closely. The principle is illustrated experimentally by means of a diode detector which was purposely made to have a very poor a-c to d-c ratio. Figure 22 shows the a-c to d-c ratio of the diode load (measured by an ohmmeter to determine R_o, and by the voltage-current method to measure Z_m) as a function of the negative resistance placed across the diode load. It is seen from this graph that the proper amount of negative resistance across the diode load causes the a-c to d-c ratio to become unity.

Figure 23 shows the distortion produced by a diode detector as a

Stabilized NEGATIVE

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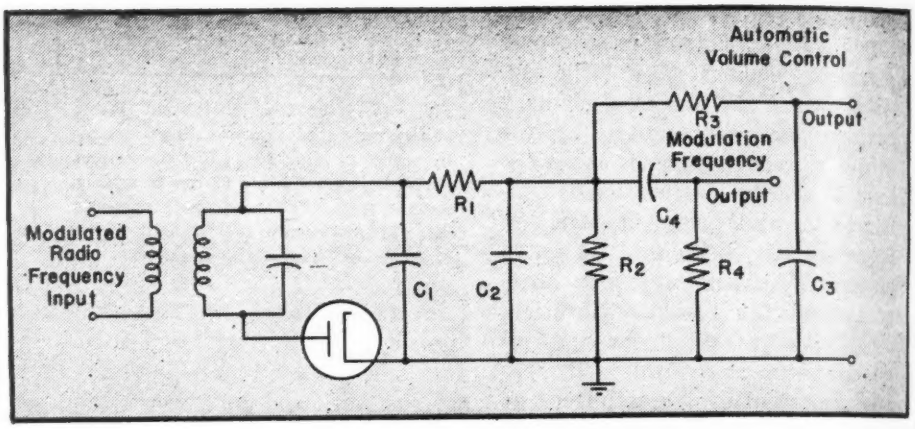

FIG. 21—Typical diode-detector circuit which can be improved by addition of negative impedance

Negative impedances are used to correct non-linearity of diode detectors by making the load ideal, to improve regulation of variable-voltage power supplies by cancelling their internal impedances, and to increase selectivity of resonant circuits by counteracting losses

BY WAY OF ILLUSTRATING types of applications to which stabilized negative impedances can be put, several specific uses will be described. The aim is more to show how one goes about utilizing negative impedances than to list their uses. Only engineering adaptability can find all the uses and the simplest methods; this merely sugests where to start.

Improvement of Diode Detector

A practical diode-detector circuit is shown in Fig. 21. The diode is used as a rectifier, being substantially a short circuit on one-half cycle, and an open circuit on the other half. The load circuit consists of a network which has several functions. The load resistance is shunted by capacitor C_1 which is large enough to act as an effective short circuit for the radio-frequency voltages and yet in an ideal case must not shunt the load resistance for the highest modulation frequency that the detector is to handle. R_1 and C_2 form a filter which isolates the radio-frequency voltage that may exist across C_1 and allows only the modulation-frequency voltage to appear across the output R_2 of the circuit. Capacitor C_4 in conjunction with the resistance R_4 separates the modulation-frequency voltage from the direct-current voltage which is present across the load circuit, a filter arrangement which is often necessary to keep d-c voltage from the following amplifier grid and to utilize the d-c voltage for automatic volume control in a radio receiver. R_3 and C_3 form a filter which isolates the modulation-frequency voltage that exists across R_2 and allows only direct voltage to appear at the a-v-c terminal.

PART I

Basic ideal circuit and fundamental equations for producing the negative of a positive impedance. Eq. (1)-(29), Fig. 1-9, Ref. 1-10

PART II

Effect on negative impedance of variations with frequency of amplifier parameters. Eq. (30)-(56), Fig. 10-20, Ref. 11-13

PART III

Illustrative applications of negative impedances show how improved circuits can be obtained. Eq. (57)-(67), Fig. 21-27, Ref. 14-16

Diode Characteristics

Operation of the diode detector has been described in literature and does not need to be repeated here.[14] It has been shown that if the radio-frequency voltage is large enough, in the neighborhood of 20 volts, then the distortion due to detection is negligible, provided that the diode-detector circuit has a pure resistance in its load for the modulation frequencies and an effective short circuit to the radio frequencies. A diode detector under these ideal conditions may be considered as distortionless.

An actual detector circuit shown in Fig. 21 is far from being ideal

function of degree of modulation for a detector which again had a purposely poor Z_m/R_o ratio in one case, and a typical one in another. In both cases the distortion of 100 percent modulated signals is very high. By means of a proper amount of negative resistance placed across the diode load, the Z_m/R_o ratio was made unity in each case and the distortion measurements repeated. The results are indicated by the solid curve.

It should be mentioned that the distortion was measured by a wave-analyzer at the output of the amplifier that supplied the negative resistance. The measured distortion in each of the three curves is the sum of all distortions due to the modulation-frequency oscillator, the modulator, the radio-frequency amplifier, the diode, and the audio-frequency amplifier used to supply the negative resistance.

The amplifier that supplies the negative resistance does not need to be a separate amplifier. The conventional radio receiver usually has two stages of audio frequency amplification after the diode detector. An addition of one resistor of proper value may be sufficient to make the Z_m/R_o ratio equal to unity and eliminate a large part of the distortion that results when high percentages of modulation are present.

Typical circuit of a diode detector and two-stage amplifier that might be found in a commercial radio receiver is shown in Fig. 24. The amplifier may be stabilized by negative feedback for better performance, but that is not essential, although highly recommended. A proper value of R_2 will develop a negative resistance of the shunt type and in combination with R_4 will form an open circuit so that the Z_m/R_o ratio will be unity.

Capacitance Multiplication

It was shown that if an impedance Z_2 was connected between the input and the output terminals of an amplifier, the input impedance of the amplifier was given by Eq. (13). If Z_2 is a pure capacitance, the input impedance of the amplifier will be a capacitive reactance whose magnitude is given by

$$Z_n = \frac{1}{j\omega C_2(1 - G)} \qquad (58)$$

If the amplifier is so arranged that the output of the amplifier will be of opposite relative phase to its input, then the gain of the amplifier will be a negative number, and so this equation becomes

$$Z_n = \frac{1}{j\omega C_2(1 + G')} \qquad (59)$$

where G' indicates that it is a negative of the previously used symbol G. The input impedance is thus a capacitive reactance, with the equivalent value of

$$C_{eq} = C_2(1 + G') \qquad (60)$$

which means that the capacitance C_2 is multiplied by the factor $(1 + G')$. It must be remembered, however, that in series with this capacitance there is a resistive component due to the inevitable output resistance of the amplifier.

Use of Negative Impedance Techniques

A pure capacitance multiplication can be obtained by a scheme similar to the method used in obtaining a pure negative reactance, If a capacitance is found to possess a certain series resistance, this can be eliminated by placing a negative resistance of the series type in series with the amplifier in the manner previously described. By making the negative and positive resistances just equal, a pure capacitance can be obtained. Another possible way of obtaining a pure negative capacitance is by utilizing a zero-output impedance amplifier.[16]

In some cases it is desirable to have a two-terminal impedance which will be small for all audio-frequencies and yet act as an open circuit for direct currents. Such an impedance may be obtained in the manner described above. In the frequency region where the amplifier supplying the multiplied capacitance has a uniform frequency response, the resistive component will be constant and its

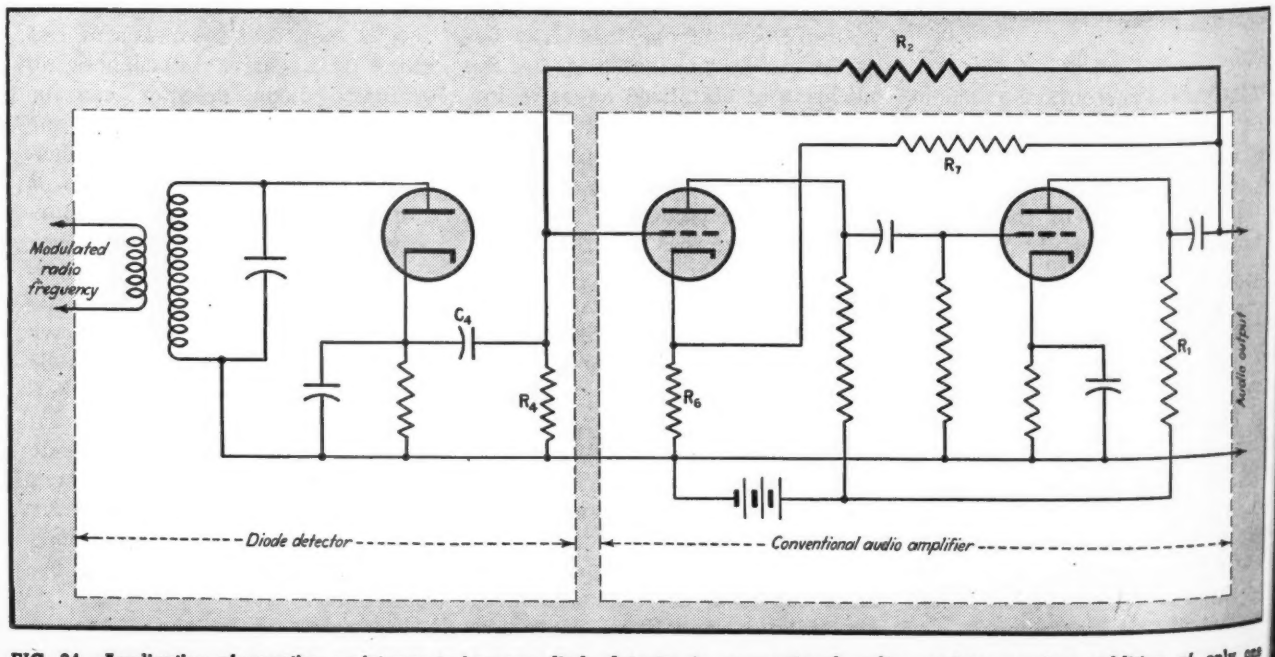

FIG. 24—Application of negative resistance to improve diode detector in conventional radio receiver requires addition of only one resistor

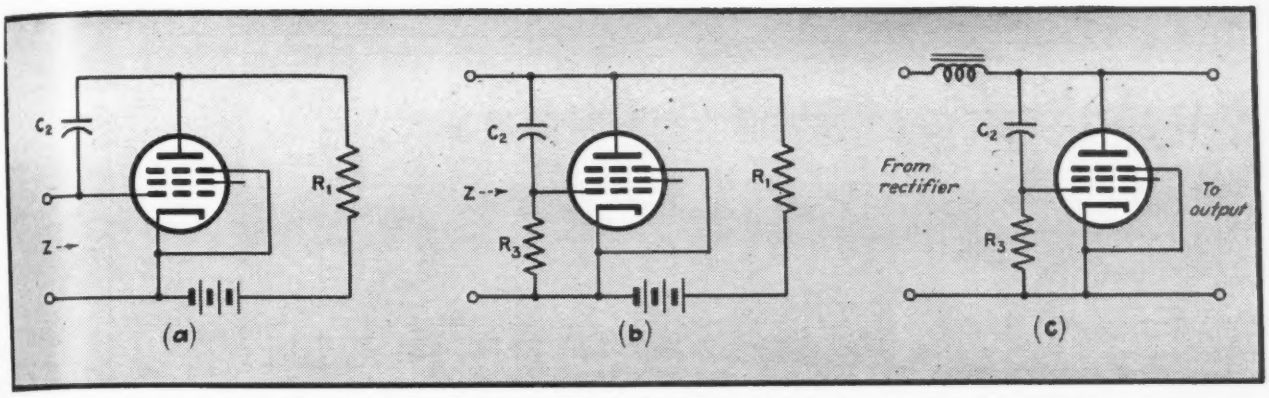

FIG. 25—Using principles on which negative impedance has been discussed, a single tube can be used to multiply capacitance as at (a) for a-c circuits, or as at (b) for combined a-c and d-c circuits for such applications as filters (c)

magnitude is given by Eq. (11) with G replaced by G'.

$$R = R_1/(1 + G') \qquad (61)$$

If C_2 is so large that the resultant circuit is merely a resistance to all frequencies for which the amplification G' is constant, the amplifier will act as a low a-c resistance, but will not pass direct current. Such an element is useful in power supply filters where it may be desired to use it as a voltage regulator or where it is desired to produce better filtering than can be done without resorting to very large capacitors. This use is illustrated in Fig. 25.

Single-Tube Capacitance Multiplier

In Fig. 25(a) is shown a single-stage amplifier which has the proper phase relations to act as a capacitance multiplier. The amplification is best obtained by means of a pentode which has a high mutual conductance. The voltage gain of this amplifier is $G' = G_mR_1$, so that the input impedance of the amplifier is

$$Z = \frac{1}{j\omega C_2(1 + G')} + \frac{R_1}{1 + G'}$$
$$= \frac{1}{j\omega C_2(1 + G_mR_1)} + \frac{R_1}{1 + G_mR_1} \qquad (62)$$

where G_m is the mutual conductance of the tube. If the reactance of capacitor C_2 is large enough, the input impedance of the amplifier will simply be $Z = 1/G_m$ providing the voltage amplification is much larger than unity.

Tubes such as 6AC7 or 6SG7 have a mutual conductance in the neighborhood of 10,000 micromhos so that it is possible to obtain an input resistance of 100 ohms for all frequencies for which the assumption made above regarding the magnitude of C_2 is true. This means that a tube of this sort is equivalent to a capacitance of 26.5μf at 60 cycles, or to a capacitance of nearly 1600 μf at a frequency of 1 cps. The capacitance of C_2 merely needs to be large in comparison to R_1 at these frequencies, which is simple because R_1 can be made as large as one desires.

A slightly different arrangement shown in Fig. 25(b) differs from the amplifier just discussed in two respects. If in the amplifier shown in Fig. 25(a) a very large resistance R_3 is placed across the input terminals, it will not affect the validity of the equations derived above. Also, if C_2 is very large, then it does not make any difference on what side of C_2 the input impedance is measured, and therefore, the equations derived for Fig. 25(a) are true for Fig. 25(b). Figure 25(b) has the advantage that a direct-current voltage may be impressed upon the device without disrupting the normal operation of the tube. Thus, this arrangement can be utilized in a power-supply filter in the same manner as an ordinary capacitor.

Further modification of the circuit is shown in Fig. 25(c) where the device is shown in a conventional power-supply filter circuit. The power supply itself supplies the necessary current for the tube and the parallel combination of load and power supply resistances constitute the equivalent of resistance R_1 of the former two circuits. In Fig. 25(b) and 25(c) the capacitor C_2 needs to be large enough only in comparison with R_3 which makes it particularly simple to obtain a device which will filter at the very low frequencies.

Negative Resistance Increases Tuned-Circuit Q

Consider a parallel combination of an inductor L and a capacitor C. If L is a pure inductance, and C is a pure capacitance, then the impedance at resonance becomes infinite. If the circuit L contains resistance R, then the impedance at resonance will be determined by the figure of merit of the circuit, commonly known as Q, which is defined as $\omega L/R_o$, and the impedance at resonance will be $R_o = \omega LQ$.

Often it is desirable to have a higher shunt impedance than can be obtained by the best coil that is available. This difficulty can be overcome by introducing either a series negative resistance in series with the coil, or a shunt negative resistance in parallel with the coil. By properly adjusting the magnitude of the negative resistance, any value of Q can be obtained from the original one up to infinity. If, for example, we let R_o' be the shunt impedance of the tuned circuit at resonance, and assume that a shunt type negative resistance of magnitude R_n is placed across the tuned circuit, then

$$R_o' = \frac{R_oR_n}{R_o + R_n} \qquad (63)$$

$$\frac{R_o'}{R_o} = \frac{R_n}{R_o + R_n} \qquad (64)$$

and the effective Q of the combination will be

$$Q_{eff} = Q\frac{R_n}{R_o + R_n} \qquad (65)$$

The stability of this increased Q must depend upon the actual increase in Q. This may be found as follows:

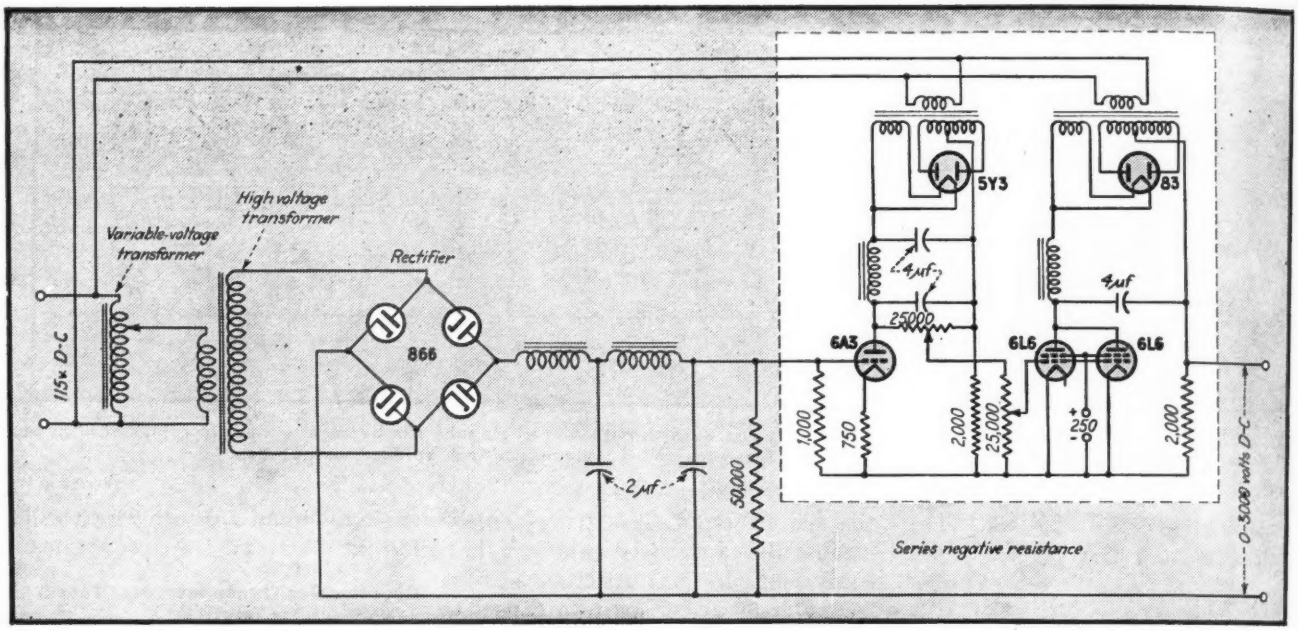

FIG. 26—Continuously-variable regulated-output power supplies can be built using negative resistance to give zero internal impedance

$$\frac{\partial Q_{eff}}{\partial R_n} = Q\,\frac{R_0}{(R_0 + R_n)^2} \qquad (66)$$

$$\frac{\partial Q_{eff}}{Q_{eff}} = \frac{\partial R_n}{R_n}\left[\frac{R_0}{R_0 + R_n}\right] \qquad (67)$$

From Eq. (67) it is plain that as R_n approaches R_0 the stability becomes very poor and at the point where Q_{eff} becomes infinite, the stability becomes infinite (See Eq. (18) and (27) and oscillations must take place. But due to the fact that the negative resistance may be stabilized very well by means of negative feedback, a considerable increase in Q is possible with reasonable stability. For instance, some stability figures were previously given for a typical amplifier. It was found that a 20 percent change in supply voltage produced a change in A of 8 percent. With $\beta = -0.1$, and $A = 10{,}000$, the stability coefficient was found to be nearly 10^{-3}, or $\partial R_n/R_n$ from Eq. (17) is $(1/1000)\,(8/100) = 8 \times 10^{-5}$ If it is further assumed that L is wound with copper wire and that a 10°C variation in temperature may take place, the original Q of the coil may vary by 4 percent. If Q_{eff} is regenerated to the point where the 20 percent variation in supply voltage will produce a 4 percent change in the Q, then $R_0/(R_0 + R_n) = 500$.

This means that by this method it is possible to increase the selective properties of a tuned circuit by a factor of 500 and still have a resultant stability which is not worse than the stability of the original coil due to temperature variations. Actually, such an increase in Q_{eff} cannot be used without providing temperature compensation.

Tuned circuits regenerated in this way have many applications. They can be used in filters, wave analyzers, or in any other application where it is desirable to have a higher degree of selectivity than is made possible by ordinary coils.

Improvement of Power-Supply Regulation

In certain applications it is sometimes necessary to have a power supply which has negligible voltage variation with changing current, or in other words, a power supply with zero internal resistance. This can be accomplished by various types of well known voltage regulators. For use with Klystrons for instance, another feature is sometimes essential: a method of controlling the voltage of the power supply continuously from zero to maximum with voltage regulation over the entire range. This requirement eliminates most of well known regulators and makes others impractical.

If a negative resistance is placed in series with a power supply and its magnitude adjusted so that it just cancels the internal resistance of the power supply, then the power supply in conjunction with the negative resistance will have a zero internal impedance and a varying load will not affect output voltage.

Figure 26 shows a schematic diagram of a power supply and a series negative resistance. Such an arrangement will make the output voltage of the power supply independent of current taken from the power supply over a wide range of voltages, because the internal impedance of power supply approximates quite well a constant. Figure 27 shows the improvement of voltage regulation of the power supply shown in Fig. 26.

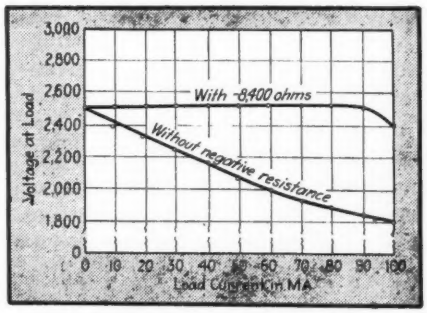

FIG. 27—Improved regulation obtained with negative resistance in Klystron power supply

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(16) Sturm, T., Verfahren zur Klirrverminderung (linearisierung), *Funktechnische Monatshefte*, Mar. 1937, p. 77-82; and Mayer, H. F., Control of the Effective Internal Impedance of Amplifiers by Means of Feedback, *Proc. I. R. E.*, 27, No. 3, p. 213-217, Mar. 1939 (Other authors have also described methods of making the output impedance of the amplifier equal to zero.).

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DETERMINING Q OF CAPACITORS

Chart minimizes calculations needed in converting Q meter readings into the Q factor values of unknown capacitors. Use of fixed capacitor in series with unknown permits extending the procedure to any size capacitor

By E. L. PEPPERBERG

Engineering Department
Zenith Radio Corporation
Chicago, Illinois

WITH the aid of the accompanying chart and a simple calculating procedure, the Q of any capacitor may be easily determined from measurements made with an ordinary laboratory-type Q meter.

The measuring procedure involves setting the Q meter to the frequency at which the capacitor Q is desired, adjusting the meter tuning capacitance C_1 to resonance when nothing is connected to the external-capacitance terminals of the meter, and reading the value of Q_1 applying to the coil used in the measurements. The unknown capacitor is now connected to the Q meter, a new at-resonance setting C_2 is obtained, and the new Q value is read on the meter. The difference between the two settings of the tuning capacitance is then the capacitance value of the unknown capacitor ($C_x = C_1 - C_2$). The first Q reading and the difference between the two Q readings are then applied to the chart to secure the Q of the unknown capacitor.

The chart is based on the equation

$$Q_x = \frac{C_x}{C_1} \frac{Q_1 Q_2}{Q_1 - Q_2} \qquad (1)$$

where C_x = capacitance of unknown unit
Q_x = Q factor of unknown unit
C_1 = initial capacitance of Q meter circuit
Q_1 = Q of coil used in measurements
Q_2 = Q of unknown capacitor and Q meter circuit combined

Three practical assumptions have been made in the derivation of this equation: (1) the unknown capacitor has a Q value greater than 10; (2) the tuning capacitor in the Q meter circuit is considered as having an infinite Q; (3) no inductance is present in the capacitors used. With these assumptions, the equation is more nearly correct at the lower radio frequencies.

If Q_2 in Eq. (1) is replaced by $Q_1 - \Delta Q$, the equation becomes

$$Q_x = \frac{C_x}{C_1} Q_1 \frac{Q_1 - \Delta Q}{\Delta Q}$$

$$Q_x = \frac{C_x}{C_1} Q_1 \left(\frac{Q_1}{\Delta Q} - 1 \right) \qquad (2)$$

The chart is based on a value of 0.5 for the ratio C_x/C_1. For other ratios, the Q value obtained from the chart should be multiplied by 2 (to eliminate 0.5), then multiplied by the actual ratio C_x/C_1.

Example 1

Values of $C_1 = 100$ $\mu\mu$f and $Q_1 = 250$ are obtained for the Q meter alone, and values of $C_2 = 50$ $\mu\mu$f and $Q_2 = 240$ are obtained with an unknown capacitor C_x connected to the Q meter. From this measured data, $C_x = 100 - 50 = 50$ $\mu\mu$f, $C_x/C_1 = 0.5$, and $\Delta Q = 250 - 240 = 10$. Tracing horizontally on the chart from $\Delta Q = 10$ to the $Q_1 = 250$ curve, then down to the horizontal reference axis gives 3,000 for Q_x. The unknown capacitor is thus 50 $\mu\mu$f and has a Q of 3,000.

Example 2

Measurements with the unknown capacitor of Example 1 at some other frequency, near the first frequency, give $C_1 = 200$ $\mu\mu$f, $Q_1 = 250$, $C_2 = 150$ $\mu\mu$f, and $Q_2 = 245$. Now $C_x = 200 - 150 = 50$ $\mu\mu$f as before, $C_x/C_1 = 0.25$, and $\Delta Q = 250 - 245 = 5$. For $\Delta Q = 5$ and $Q_1 = 250$ the chart gives a Q value of 6,000 for $C_x/C_1 = 0.5$, and applying the correction factor (because we have a different ratio now) gives $Q_x = 2 \times 0.25 \times 6{,}000 = 3{,}000$. The new frequency thus gives the same value of Q as before.

Large Capacitors

For capacitors too large to be measured on the Q meter in the above manner, three sets of measurements and additional calculations must be made, using results obtained from the chart. A small fixed capacitor C_A is required, of any value that can be measured directly on the Q meter and, with C_A in series with the large unknown capacitor, gives a combined capacitance which can also be measured.

In this procedure, the values of

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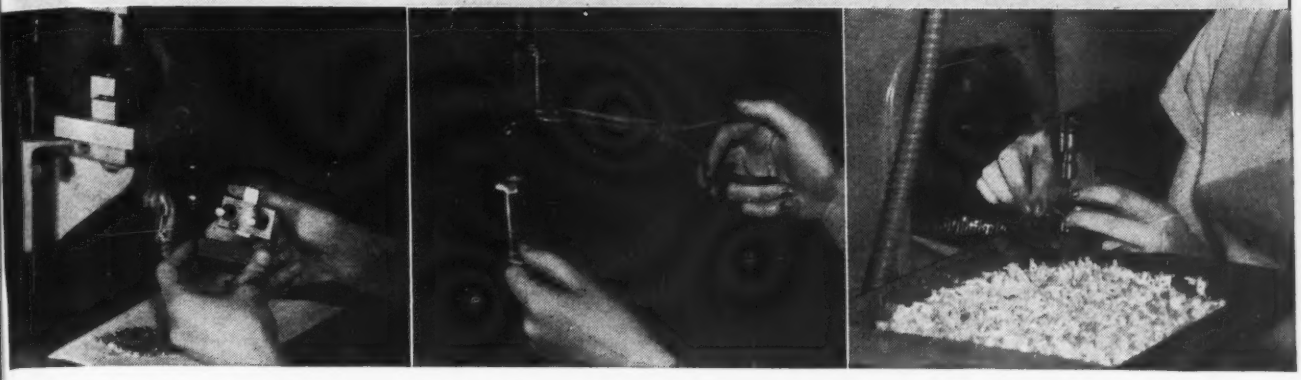

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C_1 and Q_1 are first obtained for the Q meter alone, as before. The values of C_2 and Q_2 are obtained next, with fixed capacitor C_A connected to the Q meter. Finally, the unknown capacitor C_X is placed in series with C_A, and the values of C_3 and Q_3 are obtained. From this data, the capacitance values of C_A and C_X are calculated as follows

$$C_A = C_1 - C_2 \tag{3}$$

$$C_X = \frac{C_A (C_1 - C_3)}{C_A - (C_1 - C_3)} \tag{4}$$

The Q of the fixed capacitor (Q_{X1}) is found with the aid of the chart, just as for the original procedure, and the Q of the series combination of C_A and C_X (designated Q_{X2}) is similarly obtained. The value of Q_X for the large capacitor can then be calculated from the equation

$$Q_X = \frac{Q_{X1} Q_{X2} C_A}{Q_{X1} (C_A + C_X) - Q_{X2} C_X} \tag{5}$$

This equation is based on the same assumptions as for small capacitors. In all calculations the factor 10^{-12} is omitted from capacitance values because the factor cancels out and does not affect final results.

Example 3

Q meter measurements on a fixed capacitor and a large unknown capacitor whose size and Q are desired give the following readings

$C_1 = 400\ \mu\mu f$ $\quad Q_1 = 250$
$C_2 = 100\ \mu\mu f$ $\quad Q_2 = 240$
$C_3 = 169\ \mu\mu f$ $\quad Q_3 = 180$

From Eq. (3), $C_A = 400 - 100 = 300\ \mu\mu f$. From Eq. (4),

$$C_X = \frac{300\,(400 - 169)}{300 - (400 - 169)} = 1{,}000\ \mu\mu f$$

To obtain Q_{X1}, $\Delta Q = 250 - 240 = 10$, $C_{X1} = 400 - 100 = 300$, and $C_{X1}/C_1 = 300/400 = 0.75$. For $\Delta Q = 10$ and $Q_1 = 250$ on the chart, a Q value of 3,000 is obtained. Applying the correction factor, $Q_{X1} = 2 \times 0.75 \times 3{,}000 = 4{,}500$.

To obtain Q_{X2}, $\Delta Q = 250 - 180 = 70$, $C_{X2} = 400 - 169 = 231$, and $C_{X2}/C_1 = 231/400 = 0.578$. For $\Delta Q = 70$ and $Q_1 = 250$, the chart gives a Q value of 320. Applying the correction factor, $Q_{X2} = 2 \times 0.578 \times 320 = 370$.

The Q of the large capacitor then is

$$Q_X = \frac{4{,}500 \times 370 \times 231}{4{,}500\,(300 + 1{,}000) - 370 \times 300} = 912$$

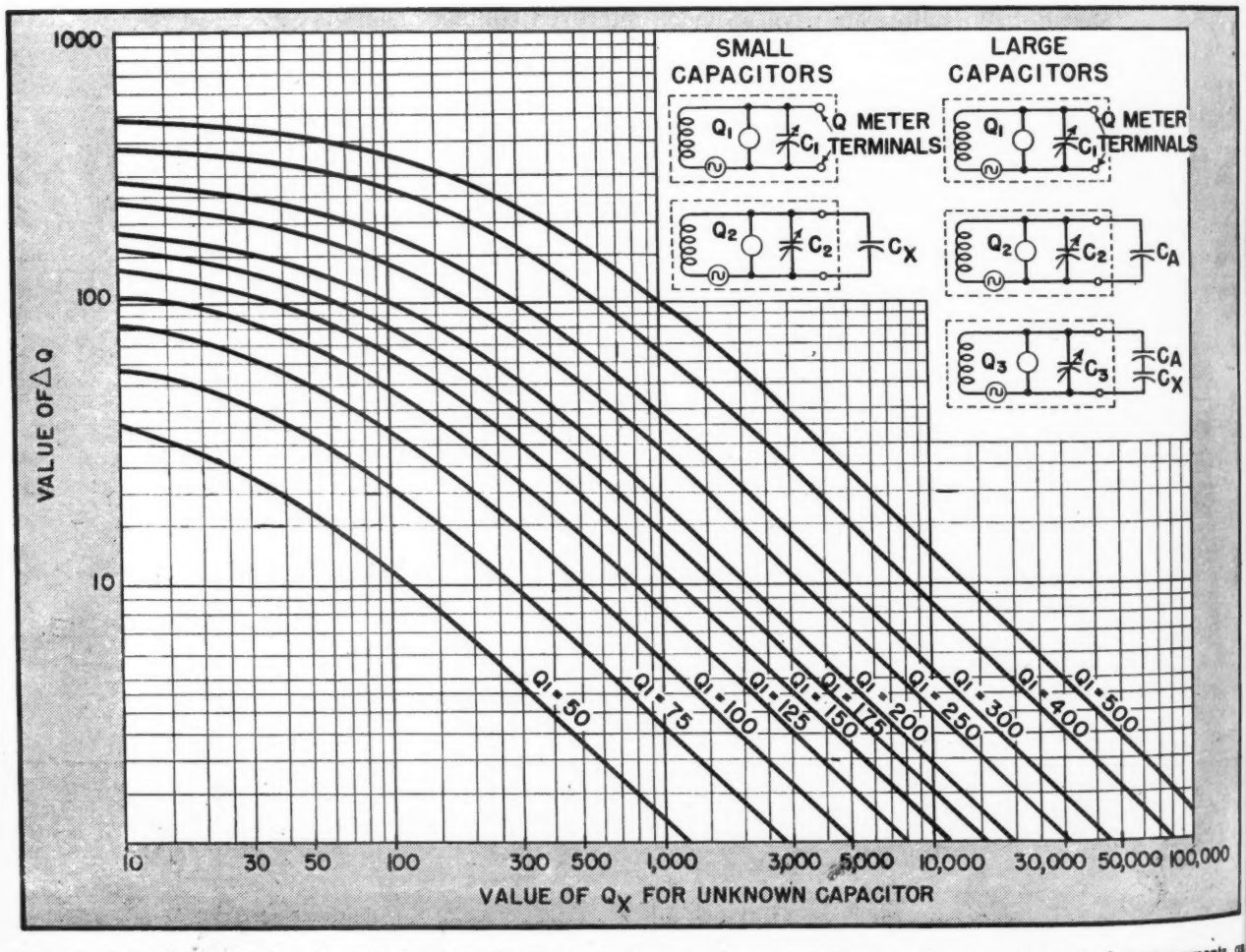
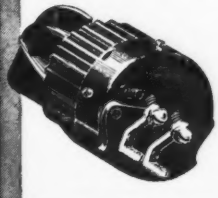


Chart for determining Q value of a capacitor from Q meter measurements. Large capacitors require one extra set of measurements, as indicated by circuits at upper right. Chart applies specifically to measurements in which ratio of unknown capacitance to capacitance C_1 inside the Q meter is 0.5; for other ratios, multiply chart value of Q_X by $2C_X/C_1$

YOUR CHECK LIST OF NEW IRC PRODUCTS

To a line of resistors already broader than that of any other manufacturer in the entire resistor industry, IRC has, in the last few months, announced several new and important contributions. Among the newer developments having wide-spread application in the electronics field are the components here briefly reviewed. All of these products are available in reasonable quantities except the Type BTR Resistor, which is still wholly allocated to a special war project. However, samples of this unit are available and will be gladly sent for test or experimental purposes. Your inquiries will receive prompt and welcome attention.

TYPE PRT POWER RHEOSTAT



Rugged yet light in weight and of neat appearance the PRT conforms fully with AN3155 specs. Has heavy screw type terminals at rear of enclosed all-metal housing. Available in 25 and 50 watt models.

TYPE BTA 1 WATT METALLIZED INSULATED RESISTOR

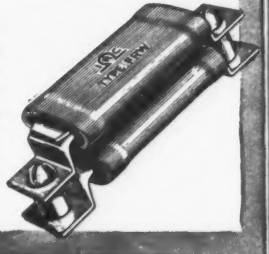
Pencil-thin, less than ¾" in length and conservatively rated at one watt the BTA is a quality resistor throughout and meets RC30 specs. Low in operating temperature it has proportionately high wattage dissipation.

TYPE BTR ⅓ WATT METALLIZED INSULATED RESISTOR

Scarcely bigger than a bump on a wire (L. 13/32"-Dia. 3/32") the BTR ⅓-watt resistor has all the quality characteristics and features that have long made IRC's BT line "Preferred for Performance." Suitable for Army-Navy RC 10 applications. *Available postwar.*

TYPE FRW FLAT WIRE WOUND RESISTOR

Efficient as a tubular wire wound, the type FRW has many features that recommend it for limited space use. In 5 standard sizes to comply with JAN-R-26, specs for RW 20, RW 21, RW 22, RW 24 requirements.



TYPE GRW GRADE 1-CLASS 1 RESISTOR

Thoroughly dependable and of sound construction these completely sealed units meet or surpass every requirement of JAN-R-26 specs. Made in 7 standard sizes with power ratings of 15 to 140 watts and resistance ranges of 0.1 to 63,000 ohms.

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Photo Timer for Time-Motion Study..... 196

Automatic Control of Vehicular Traffic

USE OF ELECTRONIC tubes in the automatic control of traffic has proved eminently practical as illustrated by applications in large and small cities and along highways. Such a system, developed by the engineers of the Northern Electric Company of Montreal, has been successfully used in Quebec for several years.

Basically there are two elements to the system, detectors and dispatchers. Dispatching of traffic is done by a control mechanism whose function is to receive the impulses from detectors, and then assign the right-of-way by means of signals, in accordance with traffic demand from instant to instant.

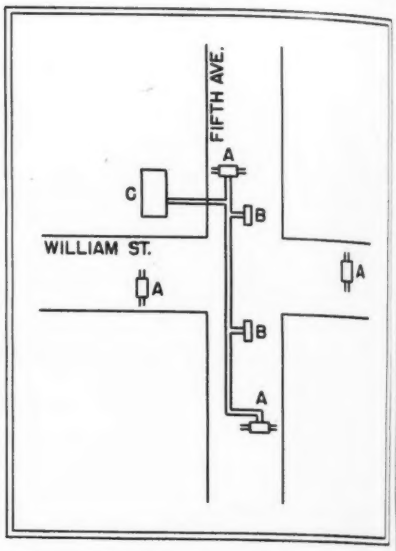
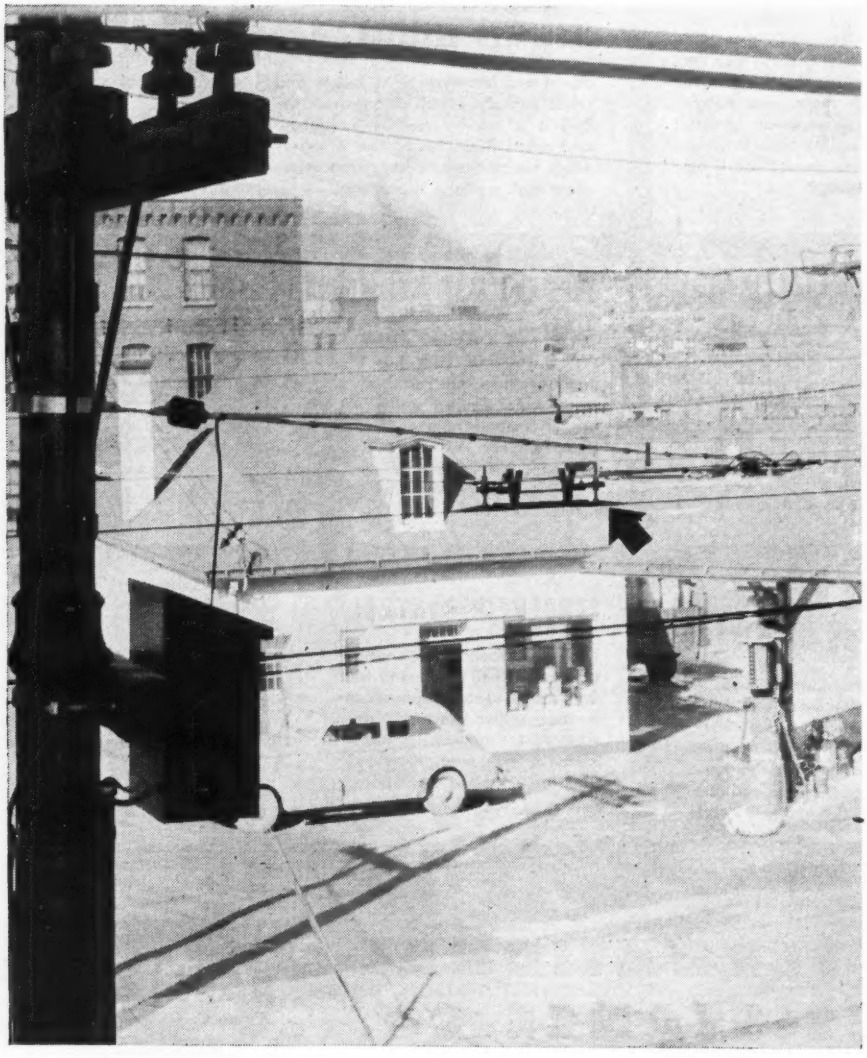


Fig. 1—Essential elements of electronic traffic control developed by Northern Electric Company of Montreal. Impulses generated by moving traffic in vehicle detectors *A*, and trolley detectors *B*, activate the dispatcher *C* to operate traffic signals



A modification of the traffic control system was needed for operation by trolley cars. The special trolley detector is mounted on the pole at the left. The contactor on the wire is indicated by the black arrow

Detectors are usually buried in the ground under the roadbed at each approach to an intersection, and may be either of the pressure-sensitive or magnetic type. In general, a vehicle passing over a detector closes a circuit (in the case of the pressure-sensitive type) or generates a minute pulse of voltage (in the magnetic type). This pulse passes through an amplifier and relay to the dispatcher, which in due course of time actuates the traffic lights. A plan of a typical installation is shown in Fig. 1. Handling the movement of trolley cars requires special consideration which will be described later.

Principle of Detector

A compensated magnetic detector is used which consists of two permanently magnetized parallel steel bars with a coil assembly mounted on each bar. The coil assemblies are hermetically sealed and the whole unit (coils and bars) is held together by means of a cast concrete block. The concrete block is cast with a splice box and a threaded conduit coupling as an integral part to facilitate cable and conduit connections.

In operation, a minute voltage is induced in the coils of the detector by the passage of a vehicle over the iron bars of the unit. This voltage, not being of sufficient magnitude to directly operate a relay, is ampli-

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fied through a vacuum-tube amplifier shown schematically in Fig. 2.

The double-bar type of detector unit is utilized for compensation against operation by current surges in nearby street car rails, power cables, etc., and to insure that the vehicle must pass over some part of the unit to provide operation. This compensation is derived by having the coil assemblies of each of the bars connected in opposition so that, in the event of a nearby current surge acting upon the bars, the voltage generated in one coil will be neutralized by the voltage generated in the other coil.

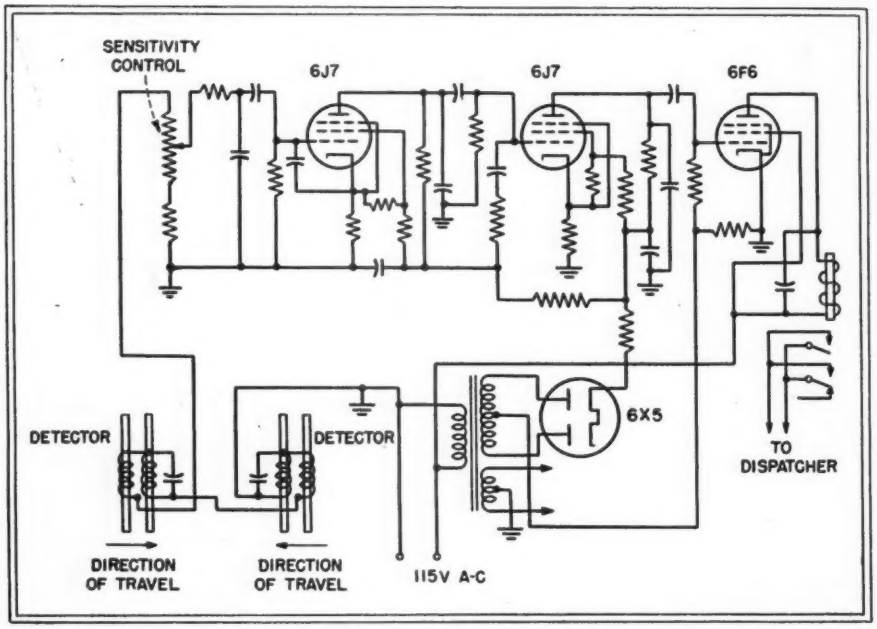

Fig. 2—Pulses from the magnetic detectors are amplified to operate the output relay, indicating a demand for right-of-way to the dispatcher

The amplifier or relay unit itself is only responsive to a positive voltage impulse on the grid of the first tube and it is this feature which makes the detector directional to a certain degree. As it is necessary for a vehicle to be in motion to operate the detector, vehicles which park nearby or directly over the detector do not cause it to be permanently energized and do not affect the normal operation. Other vehicles passing beside the parked vehicle and passing over any part of the bars will be detected.

Operation

When the axle of a vehicle approaches the unit, as shown in Fig. 3, it starts to cut the lines of magnetic force of both bars, thereby inducing a voltage in the coils with current flowing as indicated by the arrows. The coils being normally connected in opposition to each other, only a slight negative voltage reaches the amplifier due to one bar being nearer the axle than the other. As the axle passes over the first bar, the induced voltage in its associated coil reserves. When the axle is traveling between the two bars, the induced voltages in the coils of the two bars are in series and a comparatively large positive voltage impulse is transmitted to the amplifier. As the axle passes over the second bar and away from the detector, the voltage in each of the coils is again neutralized.

With vehicles traveling in the opposite direction, the reverse occurs. A comparatively large negative voltage is generated when the axle is passing between the two bars but, due to the design of the amplifier, this negative voltage impulse is not amplified. However, a car traveling in the wrong direction will generate a small positive voltage on approaching the detector, which voltage may, under certain conditions, be sufficient to operate the relay. To utilize the maximum effectiveness of the directional feature, an adjustable sensitivity control is incorporated in the relay unit and is adjusted manually by a knob on the panel of the unit. This control is adjusted to the minimum point where all vehicles approaching the intersection from the correct direction are detected.

The dispatcher mechanism is mounted in a weather-proof cabinet equipped with numbered connecting blocks and suitably labeled switches for switching on or off of the traffic lights and transferring from automatic to manual control as desired. It consists of a solenoid-operated cam shaft having six steps per cycle.

Associated with the cams are two groups of spring contacts which open or close in varying combinations according to shaft position, to set up the appropriate signal indications and to change the timing conditions as necessary. Four relays, two gas discharge tubes, a transformer and rectifier and several R-C timing circuits are also included in the dispatcher unit. The transformer furnishes the low a-c potential for the operation of the detector relays and, in conjunction with the rectifier tube, furnishes d-c for the timing circuits.

Traffic cycles of the control mechanism are divided into six intervals which consist of an initial green or go interval, a vehicle green interval and a yellow caution interval for each of two phases. The length of

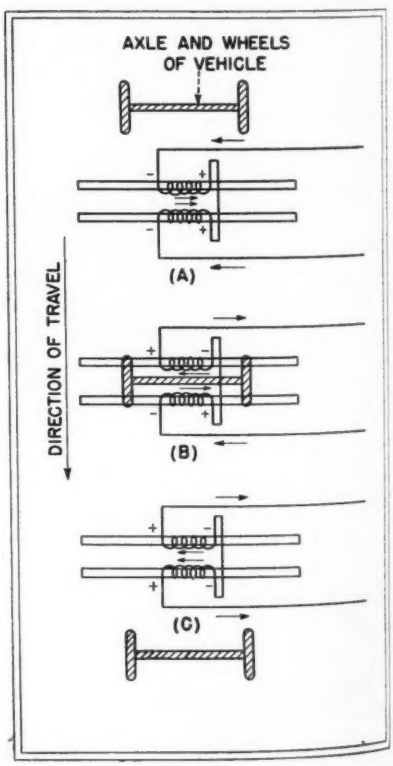

Fig. 3—Axles of moving vehicles cut magnetic lines of force, generating voltages in the inductors

Answers to your Questions about the SHURE "556" *Super-Cardioid Broadcast Dynamic*

Q. *What is meant by Super-Cardioid?*

Answer: Super-Cardioid is an improvement on the cardioid (heart-shaped) pickup pattern, which makes it even more unidirectional. "Super-Cardioid" reduces pickup of random noises by 73% as compared to 67% for the Cardioid, and yet has a wide pickup angle across the front.

Q. *To accomplish this, is it necessary to have two Microphones in a single case?*

Answer: No. The Shure "556" is designed according to the "Uniphase" principle, a patented Shure development which makes it possible to obtain the "Super-Cardioid" pattern in a single compact, rugged unit.

Q. *Over what range does the Shure "556" give quality reproduction?*

Answer: The Shure "556" provides a high degree of directivity, both horizontally and vertically over a wide frequency range from 40 to 10,000 cycles.

Q. *Does the Shure "556" reduce feedback?*

Answer: Yes! Reflected sounds and "spill-over" from loud speakers entering from the rear are cancelled out within the Microphone.

Q. *Can the Shure "556" be used outdoors?*

Answer: Yes. It is insensitive to wind and will withstand heat and humidity. The low impedance models may be used at practically unlimited distances from the amplifier.

Q. *Can the Shure "556" be used for Studio Broadcasting?*

Answer: More than 750 Radio Broadcast Stations in the United States and Canada use the Shure "556" in their studios. Because it can be placed with its back to the wall without picking up reflected sounds or echoes, it facilitates Microphone placement.

Model 556A for 35-50 Ohm circuits—
LIST PRICE $75

Model 556B for 200-600 Ohm circuits—
LIST PRICE $75

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Designers and Manufacturers of Microphones and Acoustic Devices

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CABLE ADDRESS: SHURE MICRO

SHURE MICROPHONES

each interval is determined by the setting of a variable resistor in an R-C circuit. Charging the capacitor through the resistor continues until sufficient voltage is developed across the capacitor to cause the gas discharge tube to flash over, energizing the cam-shaft solenoid to shift the cam assembly one step. As the cam shaft is rotated from step to step, a new R-C combination is switched into the circuit, making possible individual adjustments of each time interval.

Trolley Cars

Difficulty arose in the operation of the system close to electric trolley lines. Consider the operation when the trolley car arrives at an intersection and stops to receive or discharge passengers. Since the traffic detectors are placed some distance from the intersection, the halted trolley cars are now past the detector and there is no way of signaling the traffic dispatcher when the car is ready to proceed. The most economical method is to place a contactor on the trolley wire so that a movement, a few feet forward, of the car will close the contact and register a demand on the dispatcher.

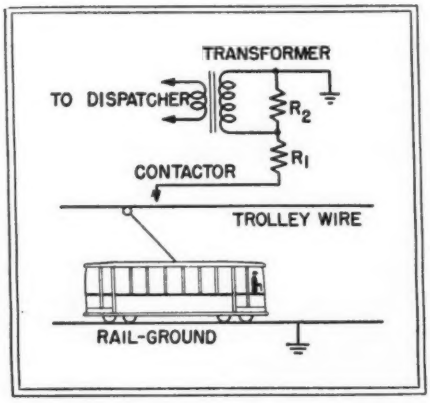


Fig. 4—Trolley closes contactor, generating voltage impulse in transformer to actuate despatcher

The first solution, involving the use of a contactor and a relay, had several disadvantages. A modification shown in Fig. 4, eliminated the disadvantages of the first idea. As the trolley moves forward, it closes the circuit to ground through the trolley pick-up unit, impressing what is in effect a unit step voltage on the transformer. The transformer isolates the dispatcher circuit from the d-c of the trolley line, but passes on the necessary impulse to register a demand for right-of-way. The voltage—divided network of R_1 and R_2, by limiting the voltage applied to the transformer primary, permits control of the intensity of the secondary pulse.

A voltage-divider network, substituting a capacitor for R_1, was considered. This arrangement, while removing all d-c from the transformer, had the disadvantage of placing high transient voltages on the circuit, making necessary special insulation on both the transformer and R_2.

Two other considerations involved secondary impedance and false operation due to transients in the trolley conductor field. Since the detectors are wired in series, it is necessary that the impedance looking into the secondaries of the individual units be low. A humbucking and shielded transformer eliminates the effect of unwanted transients.

Penicillin Drying Machine in Production

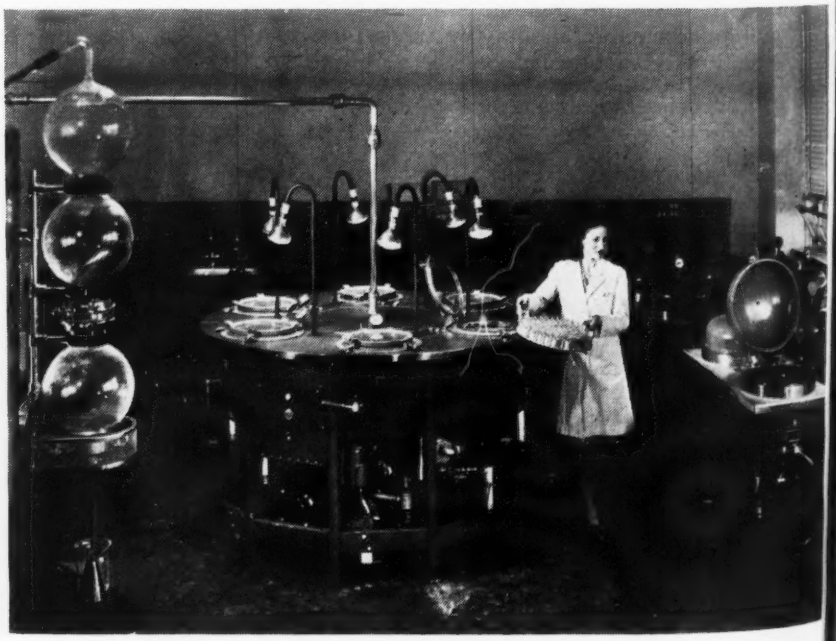
AS NOW PERFECTED for production use, the electronic drying system for penicillin that was announced by RCA Laboratories last fall can produce ready-to-use vials of penicillin at the rate of 2,000 per hour, with each vial containing 100,000 Oxford units of the renowned drug. Hourly production is sufficient to treat 400 patients requiring 500,000 units each. The system can operate as much as 20 hours a day for a total of 4,000,000,000 Oxford units.

This rate of output exceeds that of conventional equipment which occupies four times the floor space and costs triple the amount of the electronic system, according to officials of F. J. Stokes Machine Company, manufacturer of the system developed by RCA Laboratories. Cost of operation and maintenance of the electronic system fall far below that of conventional equipment.

Three Units

The system was developed by Dr. George H. Brown and his associates, C. N. Hoyler and R. A. Bierwirth, of RCA Laboratories, and consists of a bulk-reducer for dehydration, an electronic vacuum drier, and vacuum heating chambers that remove the last bit of moisture from the vials.

The bulk-reducer employs r-f current to concentrate the penicillin



Complete electronic drying system for penicillin. The three glass bulbs comprise the r-f heating bulk reducer that does in 30 minutes a dehydrating operation that would rquire 24 hours by freeze-drying. At center is the electronic vacuum drier that reduces 1-cc quantities of concentrated penicillin solution to a dry film in vials. At right are the dome heating tables where the last bit of moisture is removed from the vials

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solution to a constituency of 100,000 Oford units per cubic centimenter. A standard RCA 2,000 watt r-f generator is connected to provide dielectric heating of the contents of three large glass bulbs joined in vertical series and attached to a pump that maintains a relatively low vacuum. In this vacuum, the solution boils at 50 F. Evaporation takes place at the rate of three litres an hour, about 48 times as fast as by conventional means.

Second Generator

The electronic vacuum drier consists of six porthole-frame vacuum chambers mounted on a round table and connected to a second RCA 2,000-watt r-f generator. Vials containing 1 cc of concentrated penicillin are placed in the chambers and caused to rotate individually at 3,000 rpm, while subjected to r-f heating. In three minutes, the solution in the vials becomes a dry film.

Each chamber in the electronic vacuum drier contain 34 vials of concentrated penicillin solution, and the system is so regulated that r-f heat penetrates three of the vacuum chambers at one time, leaving the other three free for loading and unloading. Red, green and amber lights at the side of each chamber informs the operator of progress.

To eliminate the small percentage of moisture that lingers in the dried penicillin, the vials are placed in electrically heated vacuum chambers for 30 minutes.

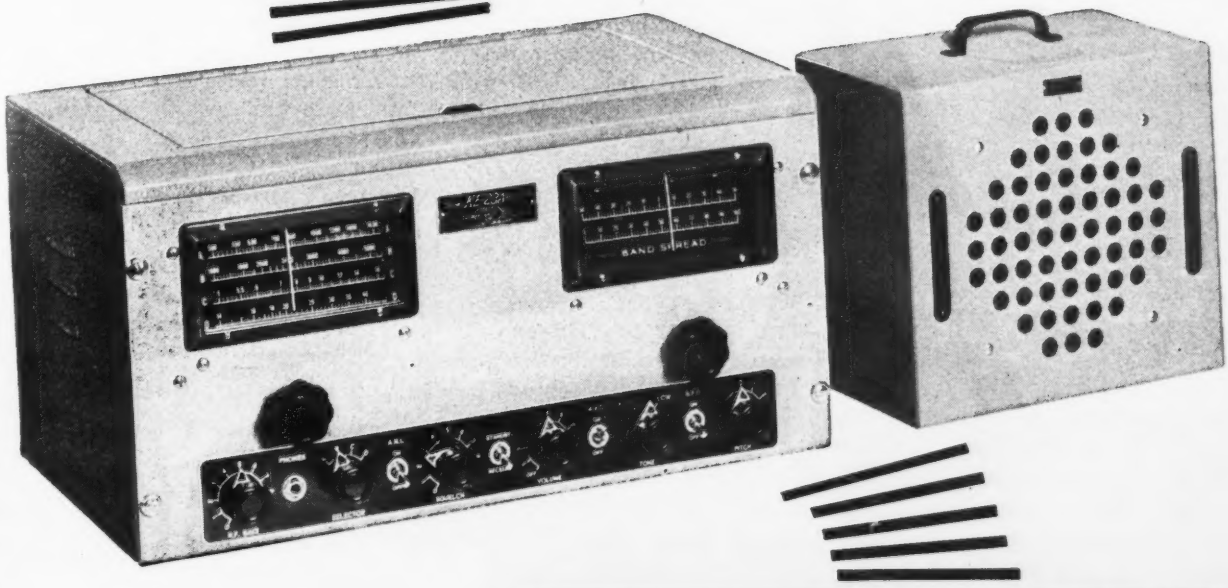
Continuous production is provided at a fixed rate of speed and may be started or stopped at will without endangering the drug under process. Development work is being continued to extend the application of the electronic drying process to many other products, such as foods, antitoxins, biologicals, and pharmaceuticals.

• • •

Industrial Control With Intercom

IN CERTAIN DEPARTMENTS of the B. F. Goodrich plant in Akron, Ohio, industrial inspectors report directly to workers involved by using an intercommunicator sys-

UP TO 42 Mc



DOWN TO 500 Kc

No-signal squelch circuit makes this general purpose KAAR RECEIVER IDEAL FOR STANDBY!

The KAAR KE-23A general purpose receiver has a wider than customary range, covering all of the radio communication bands from 500 Kc to 42 Mc. Unsurpassed for most types of emergency, commercial, and amateur operation, it is especially favored as a standby receiver.

A *no-signal squelch circuit*—normally not available in a general purpose receiver—automatically silences the speaker except when a call or message is being received, thus eliminating background noise during standby periods. A threshold control on the panel determines the amount of carrier required to operate the receiver, or cuts out the squelch circuit when desired.

This nine tube receiver has a high degree of stability and its selectivity and sensitivity insure reception under the most difficult conditions.

The KE-23A, designed for 117 volt 60 cycle AC operation, is instantly converted to 6 volt DC by plugging in a KAAR 647X power pack at the back. Write today for additional information about this versatile KAAR receiver.

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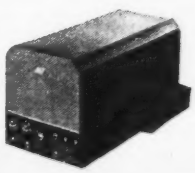

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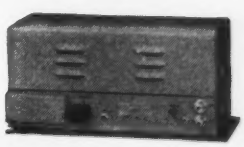

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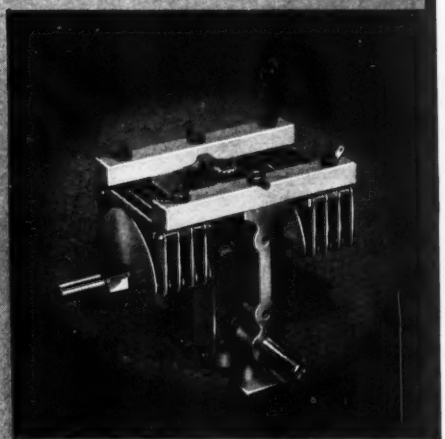

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Another Millen exclusive "Designed for Application" product. Illustrated is the 11035 size. Permits more efficient use of newer tubes—more compact and symmetrical circuit arrangements and consequent better neutralization. Center fed rotors for better high frequency current distribution. Isolantite insulation; terminals in convenient places. Sturdy cast aluminum center frame with right angle drive, 16/1 ratio. Rounded polished heavy gauge aluminum plates. Extended rotor shaft for dial or indexing device.

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tem. Seated before a microphone, the inspector can reach up and pull a callboard lever to contact the responsible worker over a loudspeaker mounted above his place of work. Thus a deficiency occurring in one heat or molding operation, for example, can be spotted before the error is repeated. The workman can answer by pressing a button.

Use of the intercom is credited with saving money and rubber and also with speeding up production of carburetor diaphragms used in large bombing planes as well as other items. Forty-one loud speakers supply two divisions of the plant and, when not being used for inspection reports, these carry music and news to the workers.

Production Tester for Small Values of Capacitance

By L. Y. HANOPOL
Technical Apparatus Co.
Boston, Mass.

THE QUALITY CONTROL and the uniformity of production demanded by present military needs has brought into effect standards set by the RMA and the Joint Army-Navy Committee, which have required greater accuracy and reproducibility of measurement of interelectrode capacitance of vacuum tubes. With the encouragement of some members of the tube industry, the design of an instrument for measuring the interelectrode capacitance of vacuum tubes was undertaken. An instrument of this type had been developed and used successfully for some time at Raytheon Manufacturing Co., whose data were released to provide the basis for commercial redesign of the instrument to permit its more general use by the industry.

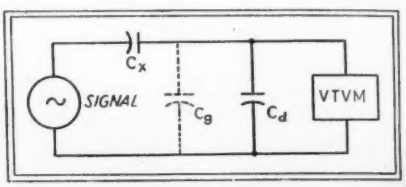

Fig. 1—Basic circuit of the vacuum-tube capacitance meter. C_x is the capacitance being measured, C_d the unknown element of the network, and C_g the capacitance to ground for the element being measured

This instrument most nearly filled the requirements desired. Es-

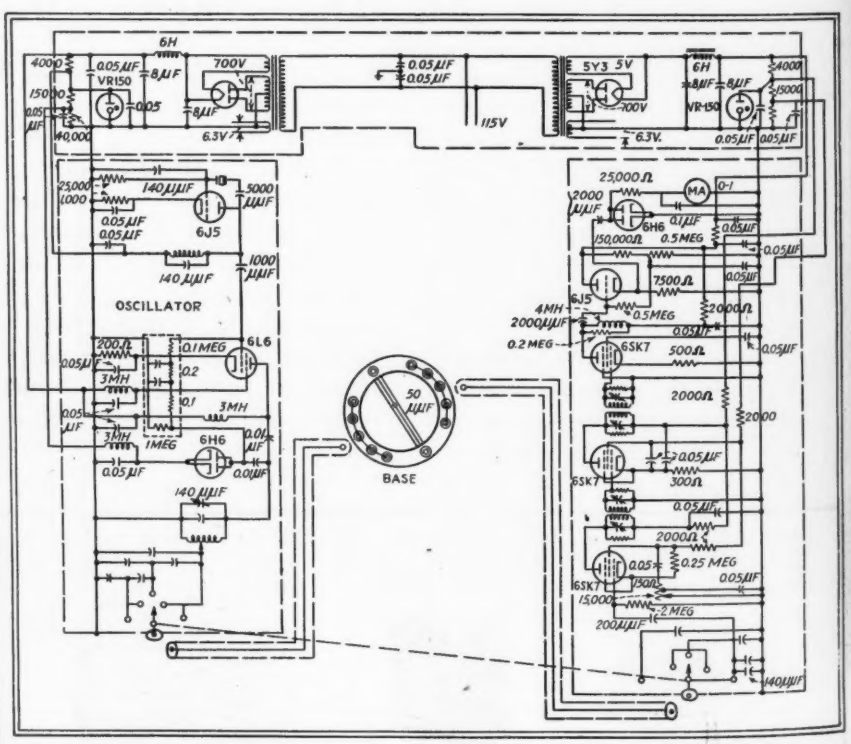

Fig. 2—Complete circuit of the capacitance meter for simple and rapid determination of very small values of capacitance

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• Lowest Rumble • Highest Efficiency
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pecially important were the use of a single fixed standard, whose magnitude made an accuracy of one-half of one percent readily obtainable, a range multiplier which could be voltage calibrated, and a direct-reading capacitance indicator.

Other Uses

The equipment will readily measure other capacitances than those between vacuum-tube elements, and adequate measurements can be obtained without shielding of the test specimen when its geometry is determinate and the sample can be directly connected to the ends of the coaxial cables. Not only may items such as small fixed and variable capacitors be measured, but characteristics which can be correlated with capacitance can be determined with the use of small samples. The precaution or limitation that variables other than the one correlated with capacitance take the form of parameters holds here and, for the many materials where this is true, measurements of thickness, dielectric constant, position, etc., can readily be made. For production testing, jigs are convenient and desirable.

Principle of Operation

The circuit of the instrument is shown in Fig. 1. When the unknown C_x is part of a voltage divider whose other element is C_d, the voltage across C_d will be proportional to C_x. The system thus requires only a constant voltage source and a high-impedance detector. Variation of range of measuring is controlled by the switching of the oscillator voltage and the dividing elements of the measuring network.

There are two limiting sources of error: first, that due to the conductance of the unknown: and secondly, the capacitance to ground, C_g, of the unknown, which changes the value of C_d, the other element of the divider. The conductance error is reduced to negligible proportions by choosing a frequency such that the conductance-to-reactance ratio is less than 0.01. Measurements show most tubes to have Q values between 100 and 200 at 465 kc. By using this radio frequency for the

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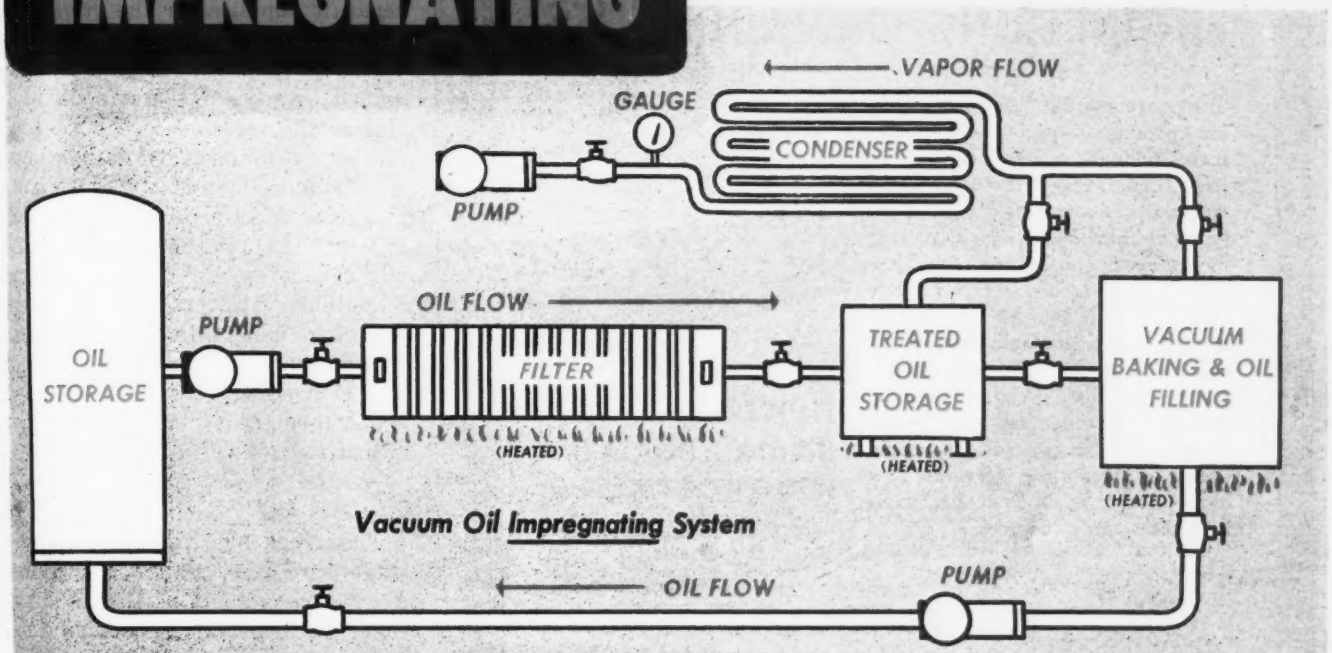

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Combination of 230 degrees F. heat and an absolute pressure of 1 mm of mercury rids oil of volatiles, air and moisture. Filter removes sludge and all foreign matter. Transformers are likewise subjected to this combination of heat and vacuum for five hours—effecting thorough dehydration. At the conclusion of this period, the treated oil is admitted to the impregnating tank, covering transformers for twenty minutes. Closure is effected under immersion (at process or room temperature as specified), then transformers are removed from bath for sealing. And this is but one of the many features of AmerTran's quality construction.

Note bellows construction of enclosing case. Compensates for pressure changes — makes possible complete filling.

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Two recent
SHALLCROSS
ENGINEERING DEVELOPMENTS

This convenient No. 759 Kilovoltmeter incorporates several features that make it ideal for either portable or fixed general use. A reversing switch makes it unnecessary to change the terminal connections should polarity be reversed. The built-in meter provides ±2% accuracy and binding posts are provided for an external meter if higher accuracy is required. The meter multiplier section is adjusted within 0.1% so that, when required, more accurate meters may be used with the external connection. This also permits the individual taps of the multiplier to be used as accurate high resistance standards.

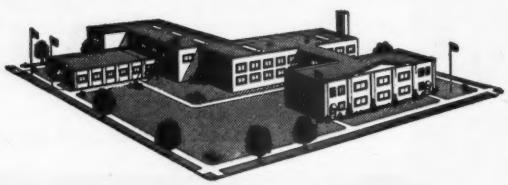
New!
5-RANGE PORTABLE KILOVOLTMETER

1, 2, 5, 10, 20 kilovolts DC at full scale.

Milliohmmeter No. 673-F is a new addition to the growing group of Shallcross direct reading resistance measuring test sets. Linear scales eliminate crowding of the higher resistance values at one end of the scale. Six scales have ranges of 0-0.5-1-5-10-50 and 100 ohms full scale, thus bridging the gap between the regular Shallcross Milliohmmeters that are extensively used for low resistance testing and the ordinary Ohmmeters used for relatively high resistance measurements. Separate connections are provided for current and potential to minimize the effect of lead and contact resistance when measuring low values. The instrument uses a single #6 dry cell battery carried in a compartment.

New!
MEDIUM RANGE MILLIOHMMETER

Six scales: 0-0.5-1-5-10-50 and 100 ohms full scale



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measuring voltage, the conductance error is lowered to a negligible value.

The instrument built along these lines consists of a power supply, oscillator, vacuum-tube voltmeter, and shielded junction block with associated tube adapters. The power supply unit is fed by a voltage-regulating transformer and comprises separate supplies for the vtvm and oscillator.

The oscillator is a crystal-controlled Pierce stage driving a 6L6 amplifier, part of whose output is fed back through a rectifier to provide automatic amplitude control. The voltage source is thus stabilized against line voltage changes, frequency drift, and output voltage amplitude variation arising from detuning and switching of load. The output of the oscillator is fed into a three-step decade attenuator which then feeds the voltage to the measuring network.

Details

The vtvm is a high-gain, three-stage band-pass amplifier, the input of which contains the dividing elements C_d of the measuring network. This amplifier is followed by an impedance-changing tube which drives the 1-ma, six-inch indicating meter through a rectifier. Meter protection is provided by the circuit

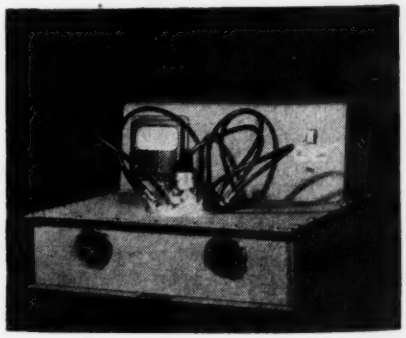

Fig. 3—Capacitance meter in use, showing a typical arrangement of cables for interelectrode capacitance measurement

overload characteristic, which keeps the meter current from exceeding 2.3 ma for any value of input voltage. The range selector is a single control driving the attenuator and the divider switches which are linked by a gear and rack drive.

Calibration of attenuator steps is accomplished by supplying voltages from a calibrated source. This

New... High melting point synthetic wax

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- Insulating Compounds
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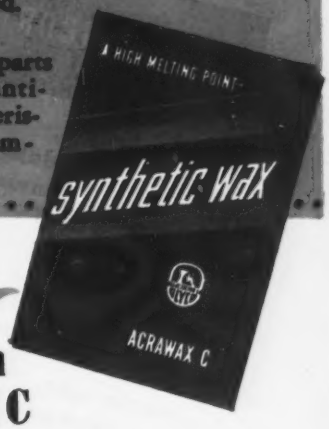
6. ACRAWAX C is compatible through hot melt procedure with a wide range of materials, many of which serve to modify it to give additional valuable characteristics such as greater adhesion, more flexible film, etc., as desired.
7. ACRAWAX C imparts anti-tack and anti-blocking characteristics to its compounds.



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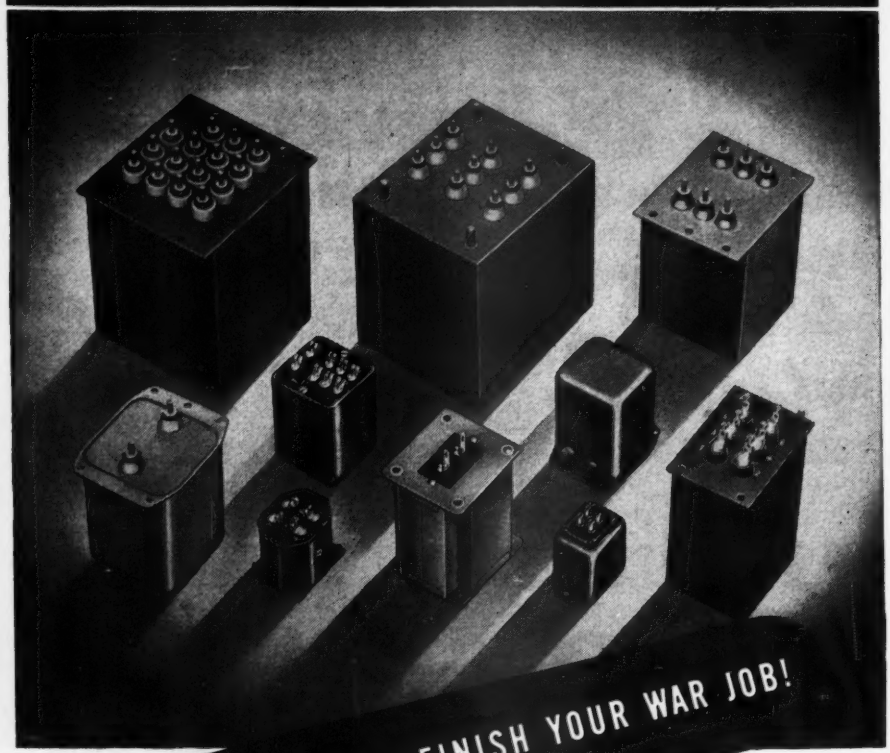

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method has two primary advantages; first, the calibration can be made against a single accurate standard of capacitance, thus obviating the need for extremely low capacitance standards which are difficult to obtain; and second, the remaining ranges can be calibrated as voltage decades from the first range. The procedure includes loading the fixed divider elements with capacitance of the order of magnitude of that introduced by tubes being measured, which provides a central value for positive and negative errors, thus doubling the value of tolerable capacitance to ground, within the assigned limits of error.

The average of a number of these instruments has indicated that limits of error are less than 3 percent, a part of which might be attributed to variations in shielding rather than to absolute error.

Special Adapters

The standards of shielding set by the Joint Army-Navy and RMA committees have been related to external tube shields and their relationship to tube elements. The various measuring methods used have had more or less completely shielded sockets and various devices for the subtraction of residual capacitances, some of which can be shown to vary with the tube in and out of

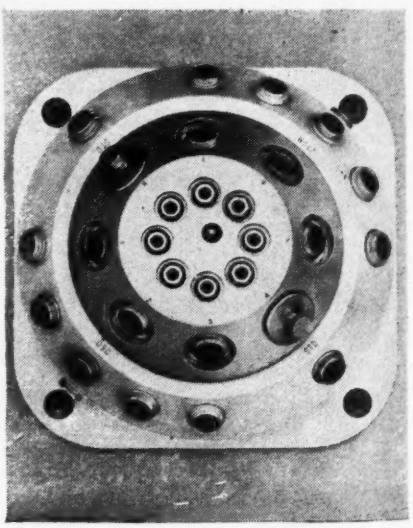
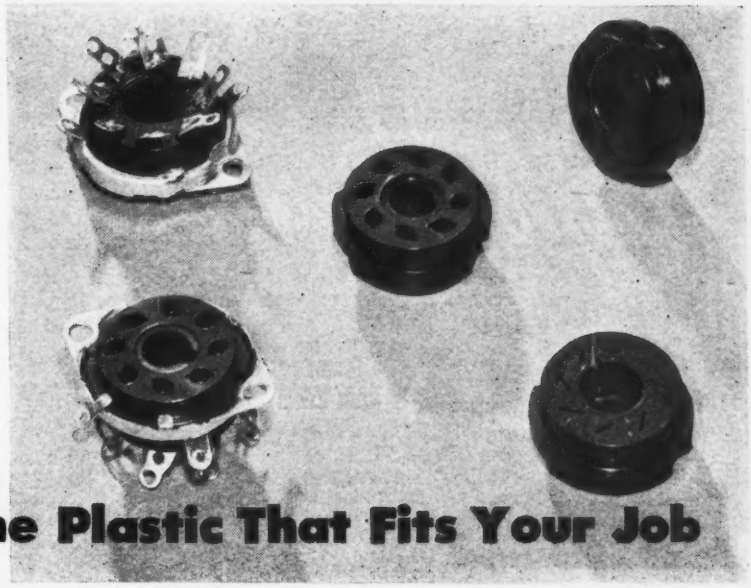


Fig. 4—Close-up view of the base into which socket adapters are plugged. The parallel banks of receptacles are used for oscillator and vtvm connections



How To Select the Plastic That Fits Your Job

During the past five years the plastics industry has grown by leaps and bounds so that today you find plastics being used extensively throughout practically all fields of business. Because they are the most versatile, the phenolics are the most widely used of all plastics. As specialists in the production of phenolics for the past quarter century, Durez makes the natural starting point for selecting the plastic that fits your job.

Typical of thousands of progressive concerns is National Fabricated Products—molders of the octal radio tube sockets illustrated. This company is well known for many outstanding contributions to the communications field and, like so many of America's manufacturers, has found the unusual versatility of Durez phenolic molding compounds of unusual value in developing complex products.

Octal Sockets

For example, these octal sockets were molded from a high-dielectric Durez compound which provides a high-voltage breakdown safety factor as well as excellent tensile strength and low moisture absorption under humid operating conditions.

Designed to use a minimum amount of chassis space, these octal sockets have self-aligning contacts which float in the molded Durez insulation and provide the necessary safeguards against fracture of the glass seal of the radio tube resulting from possible misalignment of tube pins. The exact tolerances and superb quality of the finished products attest the ingenious molding job done by National Fabricated Products and the versatility of the Durez phenolic molding compound used.

Unusually Versatile Material

Like the material used in molding these octal sockets, the more than 300 other Durez molding compounds possess many highly desirable inherent characteristics which make them extremely valuable to the imaginative design engineer. Such properties as dielectric strength, excellent moldability, highest dimensional stability, and resistance to heat, moisture, and chemicals—to mention a few—are common denominators of all Durez compounds . . . make the logical starting point in the search for the plastic that fits your job.

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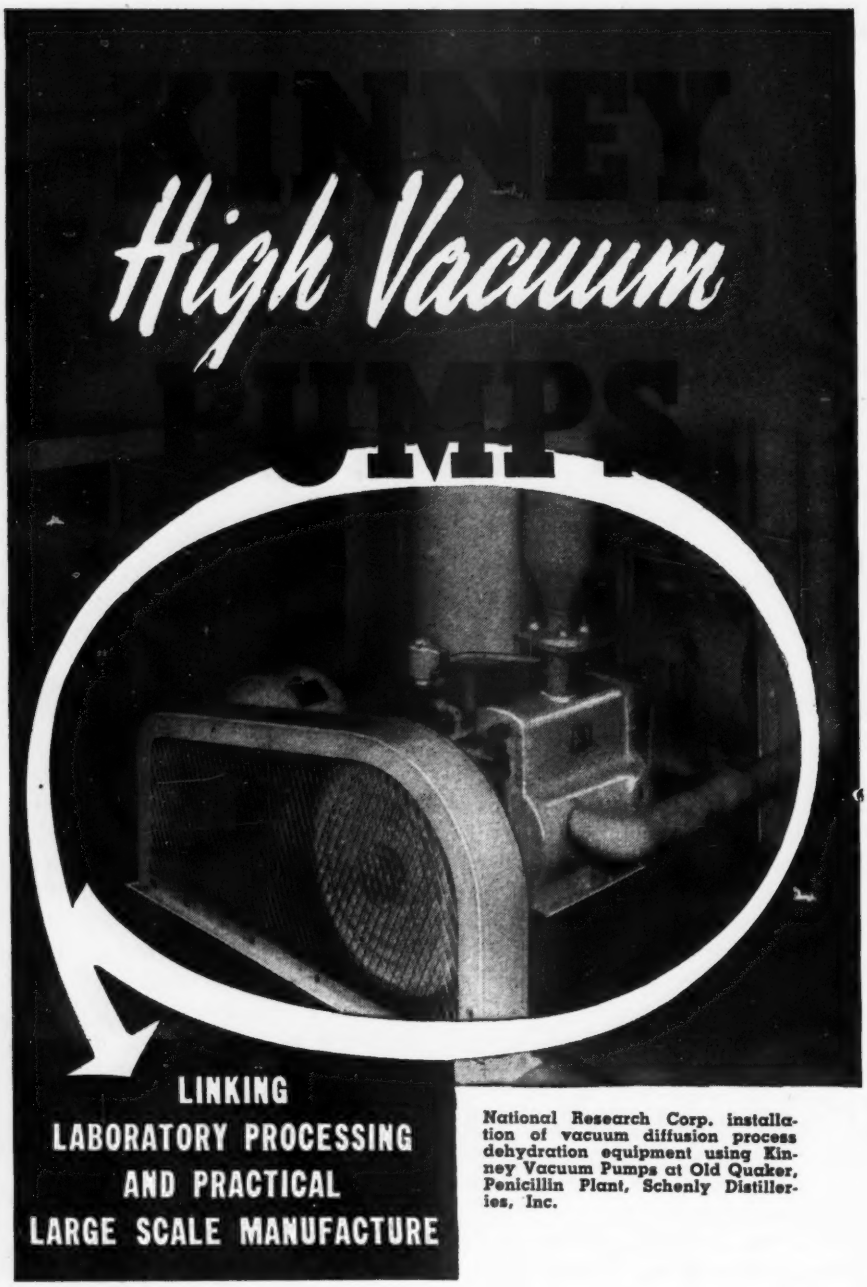

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the socket. These sources of variation are eliminated by use of an adapter each of whose contacts is in a separate, completely shielded compartment. A set of such adapters has been designed as part of the equipment.

The adapters plug into a universal shielded socket, having all the pin contacts carried through shielded chambers to a series of receptacles mounted on an inclined periphery of the socket. This socket is in turn mounted upon and shielded from a casting whose periphery carries two banks of parallel-connected receptacles. Each bank is shielded; one bank connects to the oscillator and the other to the vtvm. Patch cords between the lower banks of receptacles and the receptacles in the socket serve to connect the tube elements into the measuring circuit in any arrangement required. The base casting also contains a 50-$\mu\mu$f standard capacitor.

The efficacy of the adapter shielding is shown by the fact that the capacitance between any unused contact and a pin plugged into an adjacent contact, and projecting

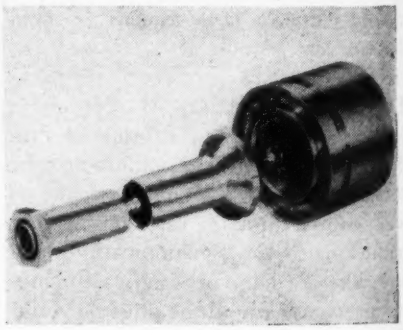

Fig. 5—Special socket adapter with shield and terminal connector for acorn tube

two inches above the top plate, is less than 0.00005 $\mu\mu$f when the whole is shielded. Interchanging of adapters does not affect the reproducibility of measurements.

The instrument is readily operated, the controls being merely those for range and calibration. The gain of the vtvm is set, with the standard in place of the unknown, for a meter reading of 0.5. The tube elements are then connected so that the unknown capacitance is between the vtvm and oscillator circuits. The shield is

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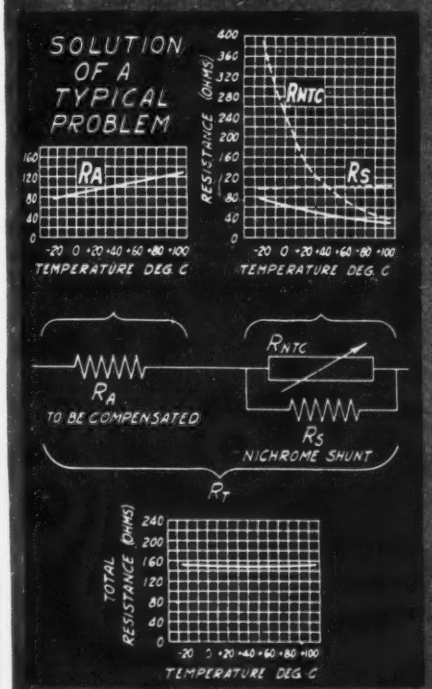

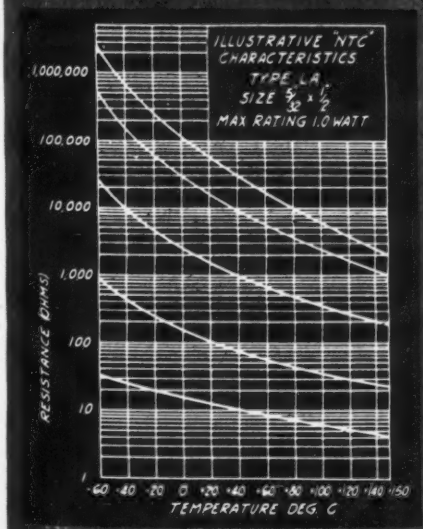

A wide range of temperature coefficients, resistance values, sizes, shapes and wattage ratings are available.

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The inherent positive temperature coefficient of copper (and many other pure metals) results in large variations in current flow and voltage drop in windings and conductors when the temperature range is great. If uncompensated, wide-tolerance performance is probable. If the percentage resistance change is minimized by adding large amounts of low-coefficient resistance, low efficiency and drastic limitation of available power are inevitable.

Because they have a large *negative* temperature coefficient, there need be only a moderate increase in circuit resistance when Keystone "NTC" units are used. The remarkable effectiveness and simplicity of this method are evident from the typical problem and its solution illustrated at the left.

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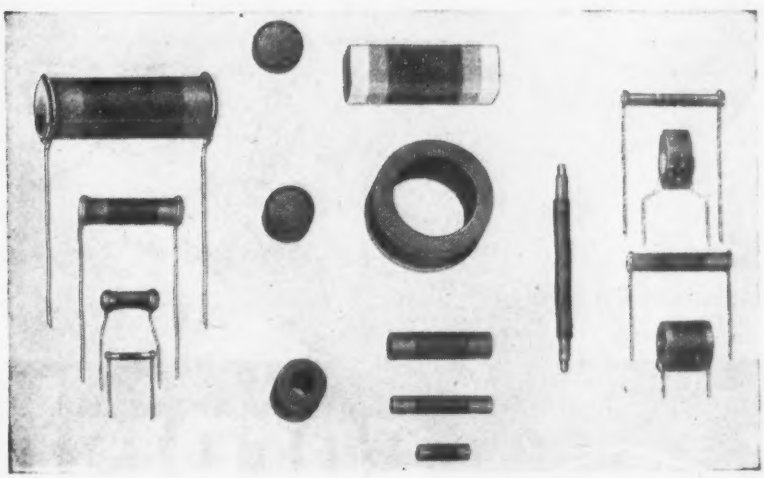

Keystone "NTC" units are thermal resistors of special composition (not carbon), developed and manufactured by Keystone, and extensively used for temperature compensation, temperature measurement and control, time delay and other applications.

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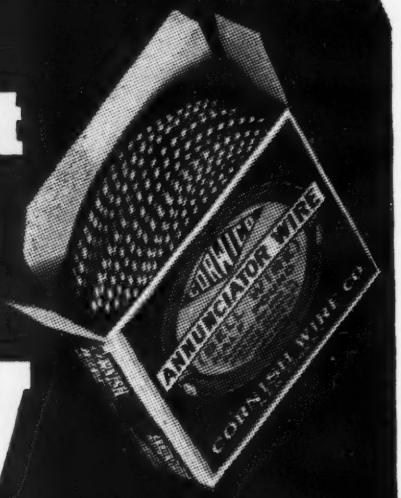

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grounded or connected to cathode, as required by the applicable test specification.

The capacitance between the tube elements being measured is the product of the meter reading and the multiplier dial setting. In the event that any of the readings fall upon the low end of the scale and greater accuracy is required, the range of the instrument can be varied by changing the calibration point; that is, calibrating at 1.0 instead of at 0.5 provides full scale ranges of 50, 5, 0.5, 0.05, and 0.005 $\mu\mu$f; calibration at 0.25 provides full scale ranges of 200, 20, 2.0, 0.2, and 0.02 $\mu\mu$f. For production testing, other points of calibration may be selected so that the limits of measurement fall on a single scale for one range setting.

The assistance of Mr. Niles Gowell, of the Raytheon Manufacturing Company, has made this project possible.

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Controlling Activation Schedules At Exhaust

BY M. SILVERMAN,
Production Manager,
Cathode-ray Tube Division
North American Philips Company, Inc.
Dobbs Ferry, N. Y.

ENGINEERS SEEM to have a habit of changing schedules—and this can at times become very troublesome to those charged with the problem of maintaining maximum production.

After two years of experimentation in our exhaust department, a standard activation schedule was evolved. With only slight variations, this system is applicable to almost every type of cathode-ray tube produced. Table I shows the basic schedule that was adopted.

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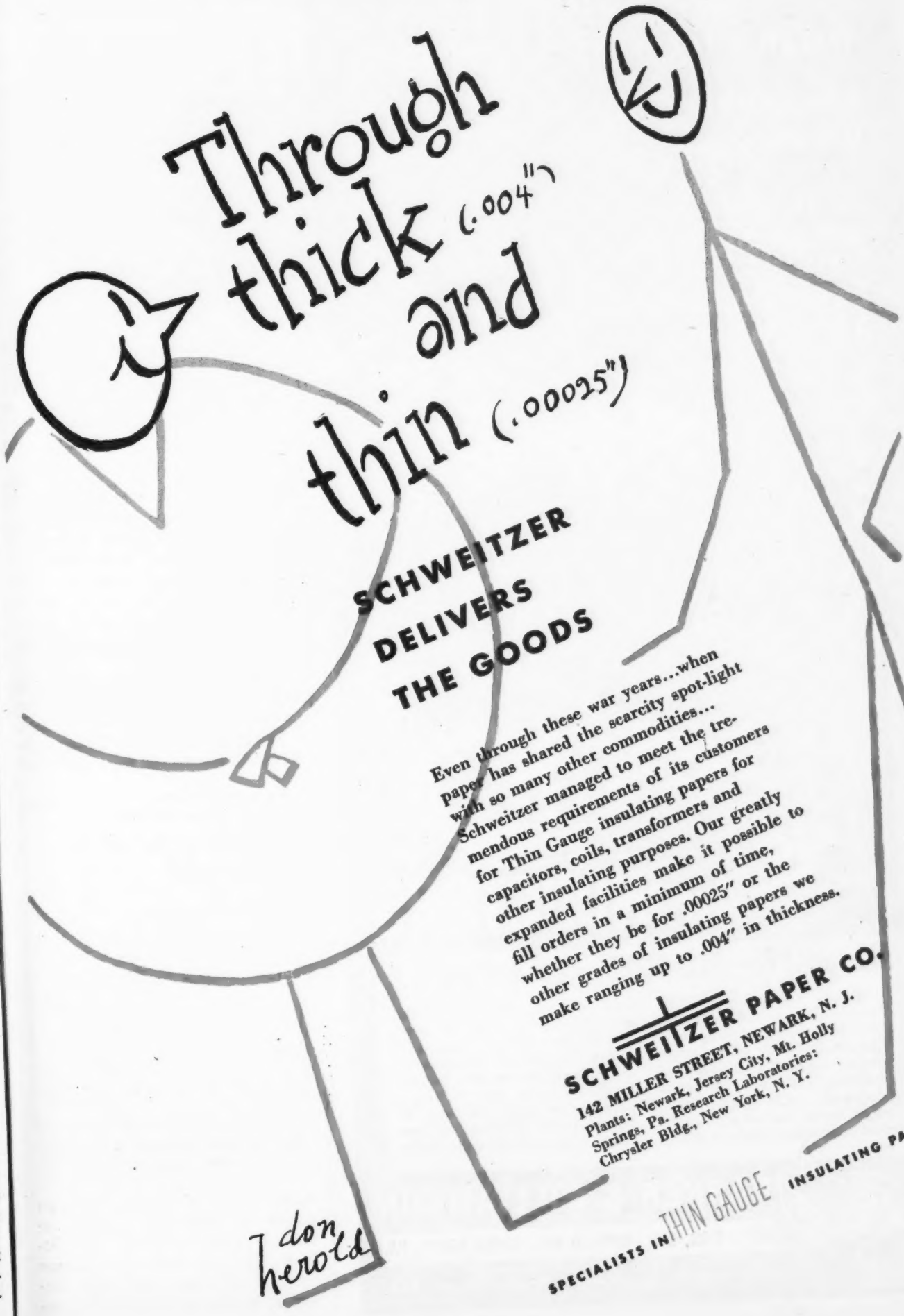

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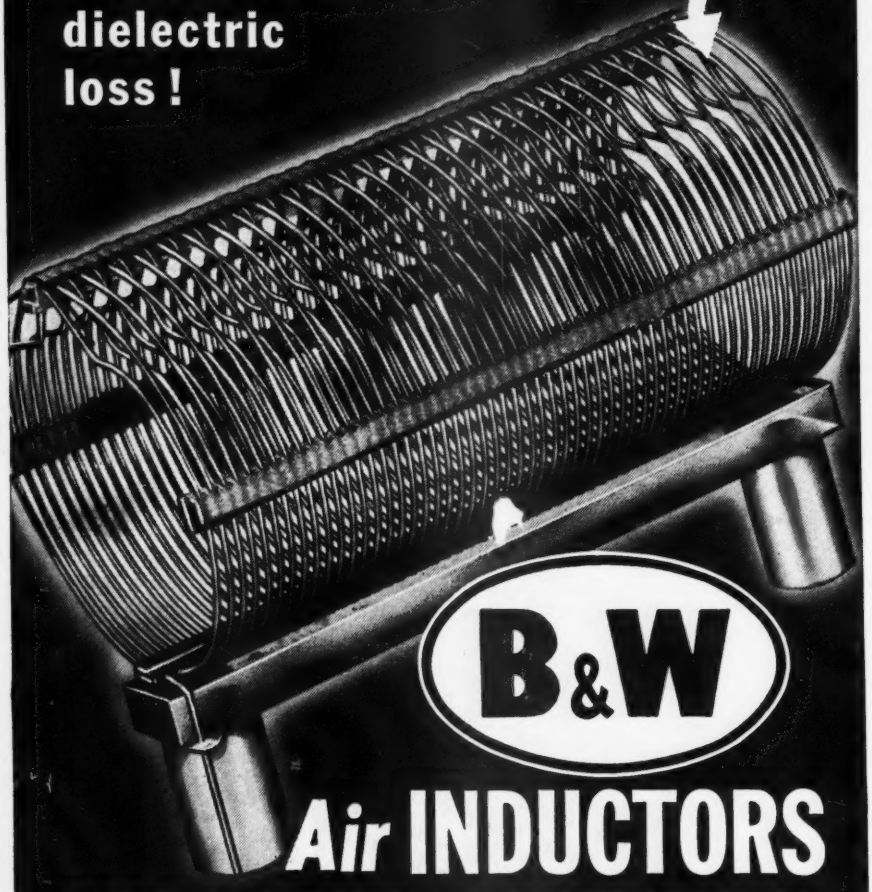

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chronous motor driving five discs. Each disc has 60 slots around the periphery and each slot represents 20 seconds of time. Two rods can be inserted in the slots of each disc. The shorter rod snaps a spring-activated switch to the on position and the longer rod turns the switch off. By correctly positioning the rods, it is possible, in one revolution, to open and close five circuits in any desired sequence using any chosen time intervals.

TABLE I—EXHAUST SCHEDULE OPERATION

Step
1 Place tube in compression fitting.
2 Open pump at stop-cock.
3 Check for leaks.
4 Light oven.
5 After tubes have cleared of color, turn on aspirator switch and lower oven.
6 Bake for 35 minutes at 400 C. At end of this period, manifold should be clear.
7 Raise oven half way and shut off gas.
8 Bombard mount to dull red. Go over twice, and pause between tubes.
9 Light heaters at 8v—2 minutes.
10 Light heaters at 9v—4 minutes.
11 Light heaters at 10½v — 3 minutes — bombard grids.
12 Connect all elements except heater and cathode to d-c and slowly raise potential to 50v—6 minutes.
13 Lower heater voltage to 9v; lower d-c to 10v and flash getters 5 minutes.
14 Tip off.

NOTE: Timer controls steps 8 to 13 on above schedule.

The complete circuit is shown in Fig. 1. Here is the way the timer works on a typical exhaust position.

Step 1—Switch 1 is closed manually. This starts the motor and lights the tube heaters. Current passes through two variable resistors in the primary, each adjusted to lower the heater voltage by some set value. The initial voltage on heaters is adjusted by a re-

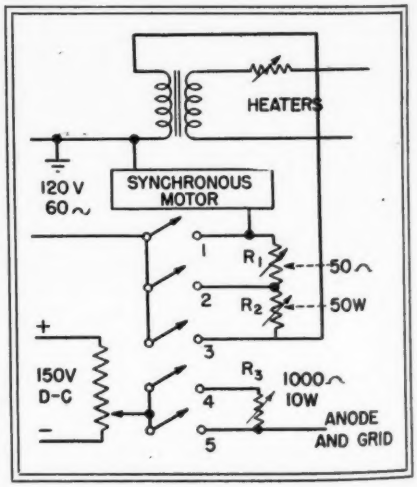

FIG. 1—Circuit diagram of automatic exhaust schedule timer

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sistor in the secondary circuit.

Step 2—Switch 2 is closed. This shorts out resistor R_1 and raises the heater voltage by one volt.

Step 3—Switch 3 is closed, shorting out resistor R_2, raising the heater voltage 1½ volts.

Step 4—Switch 5 closes and 50 volts d-c is applied to grid and anodes.

Step 5—Switch 4 closes. This has no immediate effect since resistor R_3 is shorted out by switch 5.

Step 6—Switches 3 and 5 open. This throws in resistor R_3 (which drops the d-c voltage to 10 volts) and resistor R_4 which returns the heater voltage to 9 volts.

Step 7—Switches 1, 2, and 4 open, turning everything off.

Empty Sockets

The heaters of tubes being exhausted are connected in parallel. If the number of tubes in each run is the same, the current drain will not vary significantly from load to load. When runs vary, resistors (having the same resistance as the hot heater) are connected in place of missing tubes. This maintains identical load conditions.

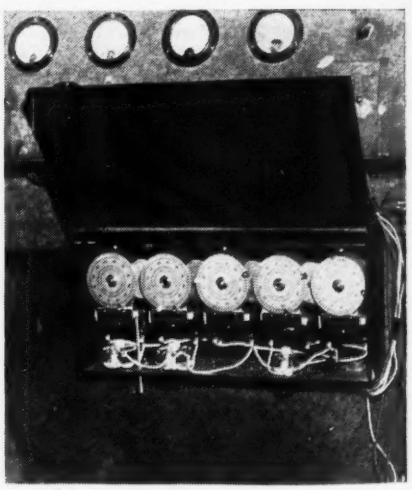

FIG. 2—Automatic timer designed to switch five circuits to permit wide choice of sequence and time intervals

Resistors R_1 and R_2 are adjusted to produce 1 and 1½-volt drops, respectively, in the secondary. Thus, once the starting voltage is set, the timer will increase heater voltage in 1 and 1½-volt steps. Resistor R_3 is set to cause a 40-volt d-c drop.

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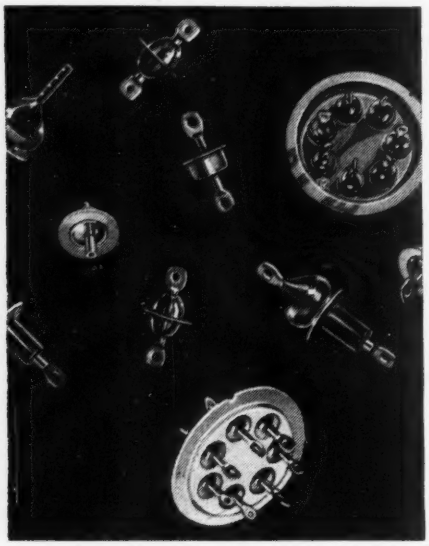

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BALLS FOR BALL bearings are automatically sorted into groups differing only ten millionths of an inch in diameter by the machine shown in the illustration. The operation is simple and consists of filling the Plexiglass hopper and removing the sorted balls a few seconds later.

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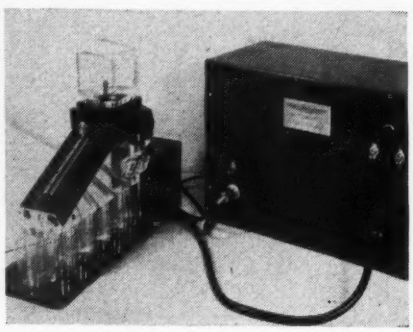

Complete equipment of the ball-sorting gage developed by Jack and Heintz engineers

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Electronic Swallow Counter

DEVELOPMENT OF THE tympanometer by the Westinghouse Research Laboratories, to determine the ease or difficulty of compensation of a flier for changes in altitude by accurately counting his swallows, has obviated the necessity of the physi-

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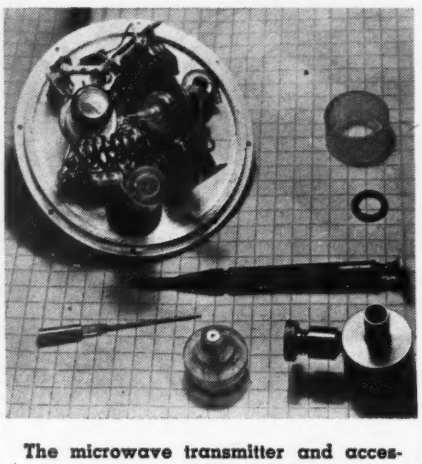
cian remaining in the high-altitude chamber during a test.

The instrument is constructed in the form of oversize earphones that clamp over the flier's head, an earpiece over each ear, and the swallows are automatically registered and recorded on a chart outside the chamber.

Each earphone contains a microwave transmitter with a short antenna. Fluid-filled chambers placed against each ear drum of the subject transmit the pressure caused



The microwave transmitter and accessories of the tympanometer for checking airworthiness of prospective fliers by counting his swallows

by a swallow to a diaphragm in the earphone. Movement of a pin attached to the diaphragm produces a peak in the output wave of the transmitter. Because the walls of high-altitude the chamber are metal, the receiving antenna is strung inside and the received signals are carried by a coaxial cable to the recording apparatus outside.

Both voluntary and involuntary compensations as related to movement of the ear drum and the rate of response of these to outside pressure variations are shown by the tympanometer. Graphs of the number of swallows, plotted against altitude or pressure, are made for use by the doctor without his presence in the chamber being necessary.

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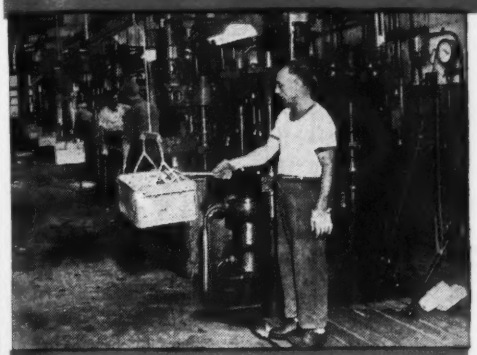

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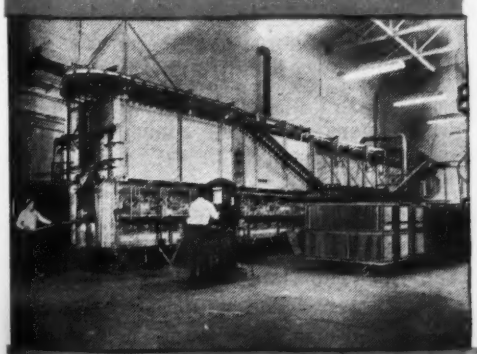

The largest sheets of mica ceramic insulation available (19¼ x 29¾) made only by Electronic Mechanics, are produced in this firing kiln followed by 12 to 36 hour annealing in the Lehr. This removes all internal stresses and strains in the sheets assuring great physical stability.

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PERFECTED MICA CERAMIC INSULATION

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IT IS now recognized by leading engineers and manufacturers that Mykroy . . . the perfected Glass-Bonded Mica Ceramic, is one of the best and most usable insulating materials yet developed for general and high frequency applications. They also know that Electronic Mechanics, exclusive manufacturer and fabricator of Mykroy, is a very dependable source of supply. Whether it is required in sheets—rods—machined or molded to specifications, Mykroy is delivered *on time!*

Mykroy speaks for itself. Although there are several brands of Glass-Bonded Mica Insulation there is a vast difference between them. Exacting tests conducted by independent testing laboratories and government agencies on samples of Mykroy picked at random from production runs have proved its superiority. (Meets L4 specifications and is approved for Army and Navy equipment.) *That is why Mykroy outsells all other brands combined!*

Electronic Mechanics, now in its tenth year, is a company of nationally known electronic engineers, who have specialized in research devoted entirely to improving the formulas and methods of processing Mykroy . . . to perfecting this extensively used high frequency insulation.

The stability of Mykroy and the company behind it are your positive assurance of superior insulation and dependable deliveries. If you have used Mica Ceramic Insulation and need more, send us your order. We'll take care of it promptly. If it's new to you, write for a sample and a complete set of Mykroy Engineering bulletins.

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This tiny gear of Molded INSUROK is the "heart" of a McGill Levolier switch. Molded to precision tolerances, it operates the ratchet device which makes and breaks the electrical circuit. Here precision, insulation, and durability are of the utmost importance.

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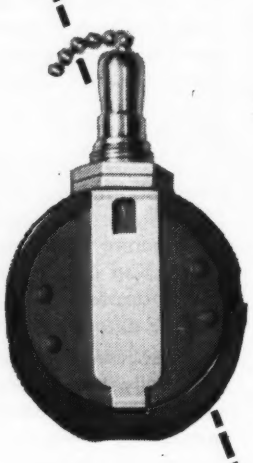
You may find, as McGill has found, that to redesign with INSUROK Precision Plastics will improve your product. INSUROK—Laminated and Molded—is available in a wide variety of grades and types. Richardson Plasticians will be glad to help you select the type best suited to your needs. Write today for information.



INSUROK Precision Plastics

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1858 INDIANAPOLIS 7, IND. LOCKLAND, CINCINNATI 15, OHIO
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CLEVELAND OFFICE 328-7 PLYMOUTH BLDG. CLEVELAND 15, OHIO

use in industry for time-motion studies of extremely high-speed subjects. The unit was originally developed by photographic engineers of the Air Technical Service Command at Wright Field, as a means of studying the effects of gunfire on armor plating. It permits taking six photographs of a 0.50 caliber bullet while it moves half its own length.

The timer synchronizes six microflash lamps so that they may be fired either in train or simultaneously. This is accomplished by utilizing linear charging of a capacitor through a pentode tube. The voltage rise across the capacitor is applied to six amplifiers which are arranged to have progressively decreased sensitivity. As the voltage rises, each amplifier is tripped in turn and the lamp to which it is connected is flashed.

This enables timing of pictures exactly, for by setting dials the operator can space the six lamps so that it takes 0.6 second for all six pictures, the slowest rate, or as little as 0.0003 second at highest speed.

Increased Range

The photographic engineering branch of the ATSC laboratory received six of the first microflash lamps ever built about a year ago. They were a development of Harold E. Edgerton of MIT. By conservative measurement, each lamp flashes in approximately 0.000002 second. They were built originally for work with small, high-speed parts at ranges of six to eight feet but ATSC photo engineers increased the range to 40 to 50 feet by using x-ray film, an *f*/2.5 night aerial camera lens and concentrated developer.

Taking pictures with the microflash units consists of opening the camera shutter in darkness, flashing the lamps and closing the shutter. The lamps may be triggered either by sounds which react in microphones, by electrical impulse transmitted by electrical circuits, such as in propeller rupture studies where the exact moment of rupture cannot be predetermined, or by light reacting on a photo tube.

MASTER audiodiscs

The excellence and consistent quality of Master Audiodiscs gained wide acceptance for them prior to the war. Now, the demand for these recording blanks, from which pressings are made, has increased more than fourfold. And here are a few of the reasons:

1. They give fine results with either the gold sputtering or silvering process.
2. Like regular Audiodiscs, the thread throws well, and there is no annoying static.
3. Cut under good recording conditions there is no audible "background scratch".
4. It is easy to ship them safely from recording studio to processor.
5. Especially important—there is no increase in surface noise from recording time to processing—be it a few minutes or many months.

Master AUDIODISCS are manufactured in three sizes on stretcher leveled No. 2 aluminum recording sheet—12", 13¼" and 17¼" for 10", 12" and 16" pressings.

AUDIO DEVICES, INC.

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they speak for themselves **audiodiscs**

TUBES AT WORK

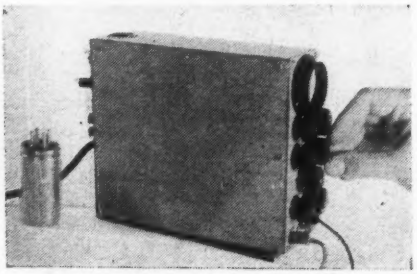
Midget CRO for Maintenance Technicians 202
VHF Omnidirectional Radio Ranges 206
Use of Shunt Diode for Supplying Bias Voltage 218
Popular Radar Tube Made in America 230

Midget CRO for Maintenance Technicians

FEATURES OF A MIDGET oscilloscope developed in England provide the kind of operation that appeals to men who are called upon to service industrial electronic equipment in several plants, each having a different power-line voltage or frequency. In addition, the instrument may be operated in the field, on aircraft, or on small boats by the use of a 12-volt battery. Total power consumption is only 15 watts whether battery or line operated.

The instrument contains a 1½-in. cathode-ray tube, linear time base, signal amplifier, and power supply and is called the Miniscope by General Electric Ltd. The complete schematic of the unit is shown in Fig. 1.

The focal properties of the small tube are reported excellent and give good definition. Brilliance and focusing controls are provided and external signals may be applied to the grid of the tube for intensity modulation. Direct access to the *X* and *Y* plates is also possible. Brilliance modulation is very useful in the examination of transients, when normal brightness obtainable would



Midget controls and a 1½-in. c-r tube permit the Miniscope panel to be only two inches wide

prove to be insufficient for the high writing speeds involved. The sensitivity of the *X* plates is 4.0 volts/mm and the *Y* plates 4.5 volts/mm. The input capacitances are about 20 $\mu\mu$f and the input resistances 3.3 megohms.

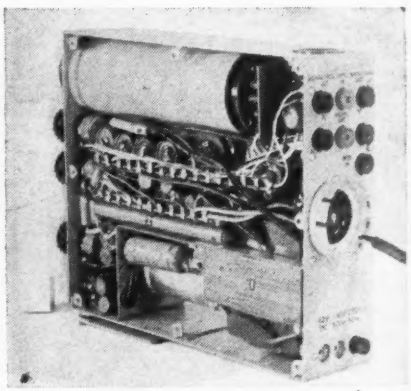
The circuit provides a time base with a frequency range of 20 to 25,000 cps for the linear horizontal sweep. Synchronization may be derived from either the observed signal, the a-c line, or any other external source.

Vertical Amplifier

The single-stage resistance-capacitance coupled amplifier uses a pentode tube and is of the usual design. The gain is continuously variable by means of the input potentiometer *G* and has a maximum value of about 400. Response is essentially flat from 50 to 10,000 cps and waveforms of only 0.1 volt can be easily examined. A separate attenuator is provided to reduce signals which are too large for direct application to the deflector plates.

The instrument is designed for operation from a 12-volt battery and contains an internal vibrator. The total power consumption is then 15 watts, the same as when the a-c line is used. This provision of battery operation makes the equipment versatile for industrial applications, in the field, aircraft, and small boats. For many wartime applications the Miniscope has proved invaluable.

High voltage is obtained from two metal rectifiers in a voltage-doubler circuit and a single source is used for the cathode-ray tube, time base and amplifier, resulting in a great saving of weight.



Compact construction of the Miniscope. The rear panel contains the input jacks and a socket for the vibrator

The internal construction of the instrument is shown.

A socket on the top of the case makes the A and B supplies available from the power pack to operate small external units which may be designed to fit on top of the instrument. This idea of providing small plug-in units for particular requirements is analogous to the interchangeable lenses of miniature cameras and enables the oscilloscope to be adapted for a vast range of uses.

Another attachment is a green

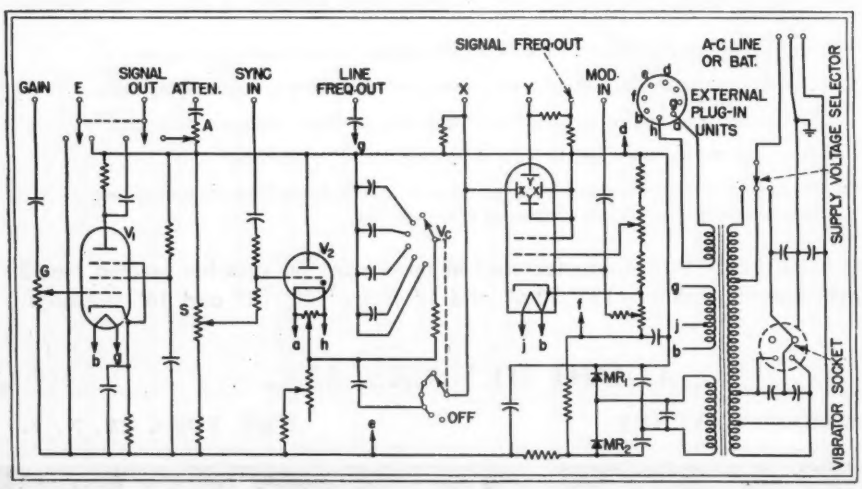


Fig. 1—Complete circuit of the miniature oscilloscope. Provision is made for operation from a 230-v, 50-cycle line, 180-v, 500-volt line, or a 12-v battery

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Litton Molube (Molecular Lubricant), a highly refined vapor pump medium, from carefully selected petroleum base, with high stability and extremely low vapor pressure, is now available in unlimited quantities for immediate delivery at prices that revise former operational economy.

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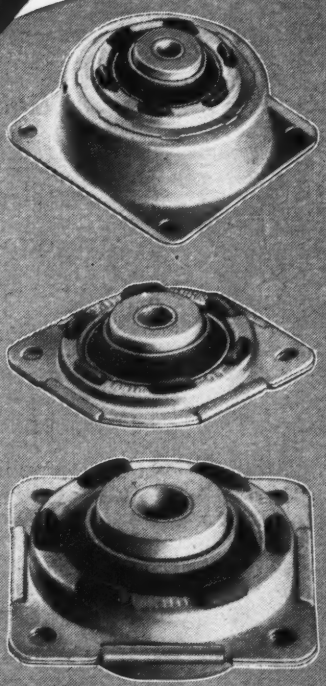

Delicate instruments such as those used on planes, radios and electronics are subject to excessive shock, jolts and vibration in their line of every day duty and need protection in order to operate efficiently for any length of time. • Harris Mounts are widely used because they cradle, cushion and protect these instruments by absorbing up to 90 percent of this jolting, jarring and excessive vibration. Harris Mounts are extremely light in weight yet are rugged and will render unusually long and efficient service. • They are made in accordance with the Army-Navy standards to suit any combination of weight, frequency, deflection or operating condition and come in both cup and plate form. • If you have a problem, just drop us a line, our engineers, specialists in the field of engineered vibration control will gladly work with your engineers. Our free bulletin series 1022 on Harris Mounts will be gladly mailed upon request. Send for it today.

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filter fitted in front of the screen. This filter renders the trace, also green, much more easily seen in daylight, since the light from it is not appreciably attenuated. External light, being reflected by the screen, thus passes twice through the filter which considerably reduces it. By this means, the apparent brightness of the trace relative to its background is increased.

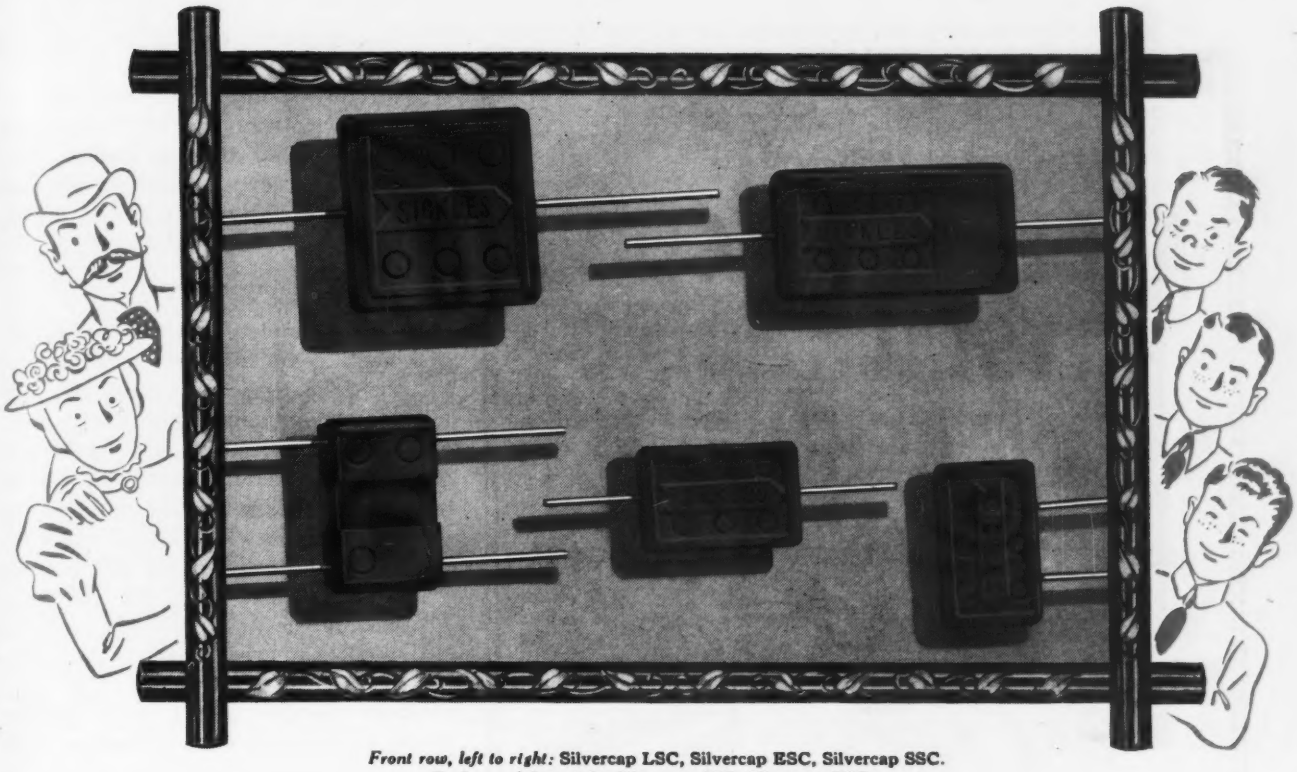
• • •

VHF Omnidirectional Radio Ranges

THE COVER OF the August issue of ELECTRONICS showed the new vhf omnidirectional radio range developed by CAA along principles proposed by D. G. C. Luck of RCA at the Kansas City meeting of RTCA in 1939. From recent developments, it now appears possible to replace the two-course vhf ranges with omnidirectional ranges in about one year. Although development of the two-course vhf system was completed in 1942, installations have been held up by the war and have only recently been resumed on a limited scale beginning with the establishment of the Chicago-New York airway.

Reproduction of the photograph that appeared on cover of *Electronics* for August. The plane is using signals from two stations 100 miles apart to obtain a position fix. The dashed lines indicate 10-degree units of azimuth transmitted by the new CAA vhf system

The omnidirectional range may be likened to the standard four-course aural radio range with a means provided for precisely determining the ratio of the two signals



Front row, left to right: **Silvercap LSC, Silvercap ESC, Silvercap SSC.**
Back row, left to right: **Silvercap ASC, Silvercap BSC.**

The Sickles "SILVERCAP" Family

SEPTEMBER, 1945

Way, way back in the early 30's, Sickles presented the first *Silvercap* Condenser, a vast improvement over its ordinary mica predecessor. The *Silvercap* used silver conducting surfaces bonded to their mica dielectric. Thus, motion between plate and dielectric was eliminated and a highly stable, uniform unit was the result.

Years of research and development followed this first model until today, the *Silvercap* family can count five highly improved members. All are made with the highest quality mica and molded with the best grade of red phenolic. These, and careful attention to details, combine to produce a unit that is unexcelled for a dependable, permanent, accurate block of fixed capacity.

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ANGLE CORRECTION CRYSTAL EDGING MACHINE

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at any point and thereby the azimuth from the station at any point, rather than at points lying only on certain specific courses where the signal ratio is unity, as in current practice.

Antenna System

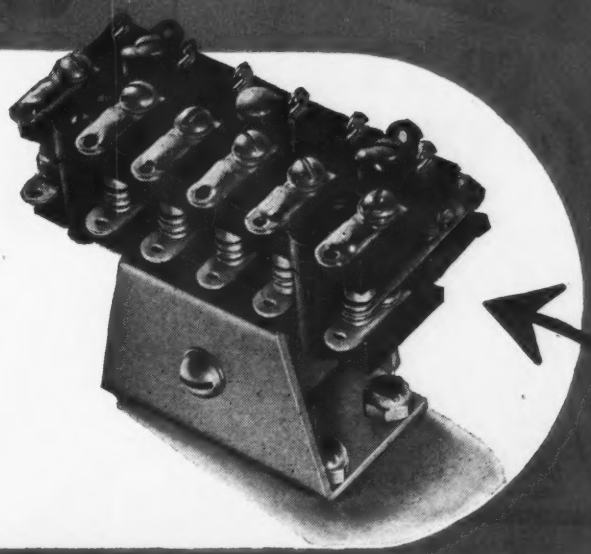
The complete transmitting equipment comprises the transmitter, the subcarrier modulator, the goniometer, and the antenna. Five radiating elements are located at the corners and at the center of the customary square employed in d-f systems. Opposite pairs of antennas are operated 180 degrees out of phase and the electrical spacing between the elements is small compared to the wavelength so that a figure eight field pattern results. This field pattern is caused to rotate by means of a capacitance goniometer which is driven by a synchronous motor at 3600 rpm.

The rotating goniometer acts as a balanced modulator. It eliminates the carrier frequency, and supplies sideband energy at carrier frequency plus and minus sixty cycles to the two antenna pairs. Since the entire field is in effect rotated once for each rotation of the goniometer, each direction in space will have a certain phase of the rotational frequency associated with it and this phase will change degree for degree with a change in azimuth relative to the station. If then we have a signal supplying a voltage of reference phase which is independent of azimuth, we may determine azimuth from the station by comparing the phase of the two received signals.

Reference Modulation

The reference signal is provided by means of sixty-cycle modulation applied to a 10-kc subcarrier which in turn modulates the carrier radiated from the center antenna. The 60-cycle modulating voltage for the reference phase signal is derived from a small alternator driven on the shaft of the motor which rotates the goniometer, so that a constant phase relationship is always maintained between the two signals. With one diagonal antenna pair accurately aligned in the local meridian, and the other

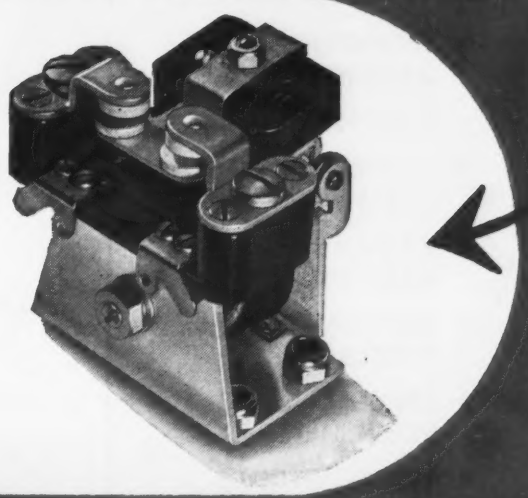
Here is *advanced* Relay Engineering!



TYPE BN

The Allied 6-pole, double-throw BN type embodies many new improvements for heavy duty 6-pole switching . . . permits individual adjustment of contacts. Molded Bakelite is used throughout the relay. Contacts are rated at 10 Amperes. As in all Allied relays, the BN is designed for compactness and minimum weight. May be furnished normally open or normally closed or double-throw. Available in AC or DC. Weighs 11 oz. Write for complete operating characteristics, etc.

Height: 2 9/16" Length: 3" Width: 1 23/32"



TYPE CN

The CN relay is the result of advanced engineering technique and succeeds Allied's successful AN type . . . a power relay expressly designed for breaking heavy current. Contact rating is 50 Amperes at 24 Volts DC with silver contacts; with alloy contacts the contact rating is 75 Amperes at 24 Volts DC. *(The latter arrangement with the alloy contacts is known as the CNS type.)* The contact arrangement is single pole, single throw, double break, normally open or normally closed. The new design incorporates molded Bakelite insulation, greater electrical clearance and over-all improved mechanical structure. Available in AC or DC. Complete data on request.

Height: 2½" Length: 2¼" Width: 2"

The two relays described above are typical examples of the many new types of relays Allied is constantly designing for its customers' widely diversified requirements.

Allied's engineering staff continually works to improve relay designs and to develop new magnetic control devices for present and future manufacturers whose products require electrical control. The highly practical accumulated knowledge of these men is at your command. Send us your control problems!

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pair at an exact right angle, the practice is to have the voltages from the two signals in phase in the true north direction with clockwise rotation of the pattern.

The total signal consists of a carrier which is amplitude-modulated so that the phase of the modulation is directly equal to the azimuth angle. The carrier is further modulated by the reference phase subcarriers. These may be separated in such a way as to leave the above result unaffected.

Receiving Equipment

The receiver is a conventional vhf superheterodyne up to and including the second detector. At this point, a filter, separates the 10-kc subcarrier, and another detector separates the reference phase voltage from the modulated subcarrier. The reference voltage is then amplified, split in phase, and applied to the two primary windings of a magnetic phase shifter. The output of the phase shifter feeds a wattmeter circuit together with a voltage derived from the variable phase signal. The indicating element of the wattmeter circuit is a standard zero-center meter which is used in aircraft as the course indicator.

A circular scale on the phase shifter is graduated in degrees from zero to 360 and an indicating pointer is attached to the rotor shaft. After the station is tuned in, the phase shifter is rotated manually until the pointer is centered. The azimuth from the station is then read from the scale on the phase shifter.

Indicators

A course along the azimuth line may then be flown by reference to the zero-center meter, which will indicate deviations from the course by deflections in the corresponding directions. When courses are flown along lines which do not pass through the station, a continuous check on azimuth from the station may be maintained by keeping the meter centered by manual adjustment of the phase shifter.

The azimuth may be indicated automatically and continuously by a means similar to that used with automatic direction finders. Such

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Severest wartime uses prove beyond question the superior qualities of all three BH Fiberglas Sleevings in electrical applications for home and industry. One of them may fit your needs to a "T"—*plus!* Write for free BH samples today and put them to the toughest tests your product can dish out!

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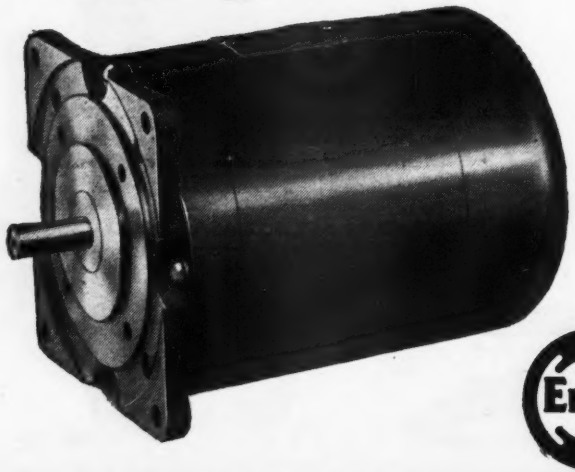

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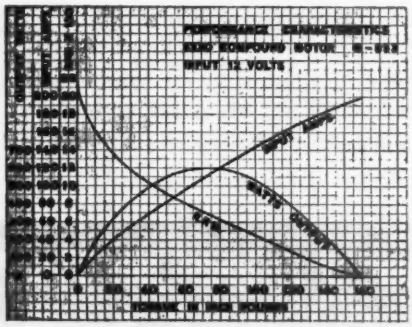
This motor was the answer to a customer's question . . . "Will you design a totally enclosed dual motor unit to drive our warehouse trucks?" Today Type 5230 motors, thousands of them, are wheeling industrial loads. Such engineering service, instantly available, may also solve a difficult motor problem for you.



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5200 FRAME MOTORS		5220 Shunt	5230 Compound
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Torque at 3900 RPM	(in. lbs.)	4.5	
Torque at 1625 RPM	(in. lbs.)		10
Lock Torque	(in. lbs.)	45	160
Volts input	(min.)	6	6
Volts input	(max.)	110	110
Diameter		5¼"	5¼"
Length less shaft		8"	9"
Shaft Dia.	(max.)	½"	½"
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an indicator is now available commercially which operates on 400 cycles. A similar instrument is being developed to operate on sixty cycles for the omnidirectional range.

Advantages

At present, the omnidirectional range has an overall accuracy of approximately three degrees. This compares very favorably with accuracies obtainable in any range or d-f system suitable for use over moderate distances and providing at least on and off course indications over the entire 360 degrees.

The omnidirectional range is an improvement over any device so far proposed in that it provides a continuous indication of azimuth in all directions without ambiguity. When used together with a distance indicator, a continuous indication of position is obtained which completely solves the navigation problem.

• • •

Use of Shunt Diode for Supplying Bias Voltage

IT IS AN UNFORTUNATE fact that radio men in general do not recognize the full potentialities of the shunt diode. In the two bias supplies to be described, shunt diodes are used for rectification with attendant advantages.

The conventional bias supply for amplifier use is shown in Fig. 1. In this circuit, a diode (usually a

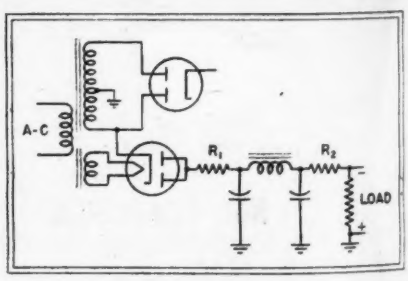

Fig. 1—Conventional method of obtaining bias from the high-voltage winding of the power transformer

6X5) is reversed and used as a half-wave rectifier for negative output. Because the heater-cathode rating will usually be exceeded, it is necessary to use a separate heater winding which frequently

WALDES

TRUARC

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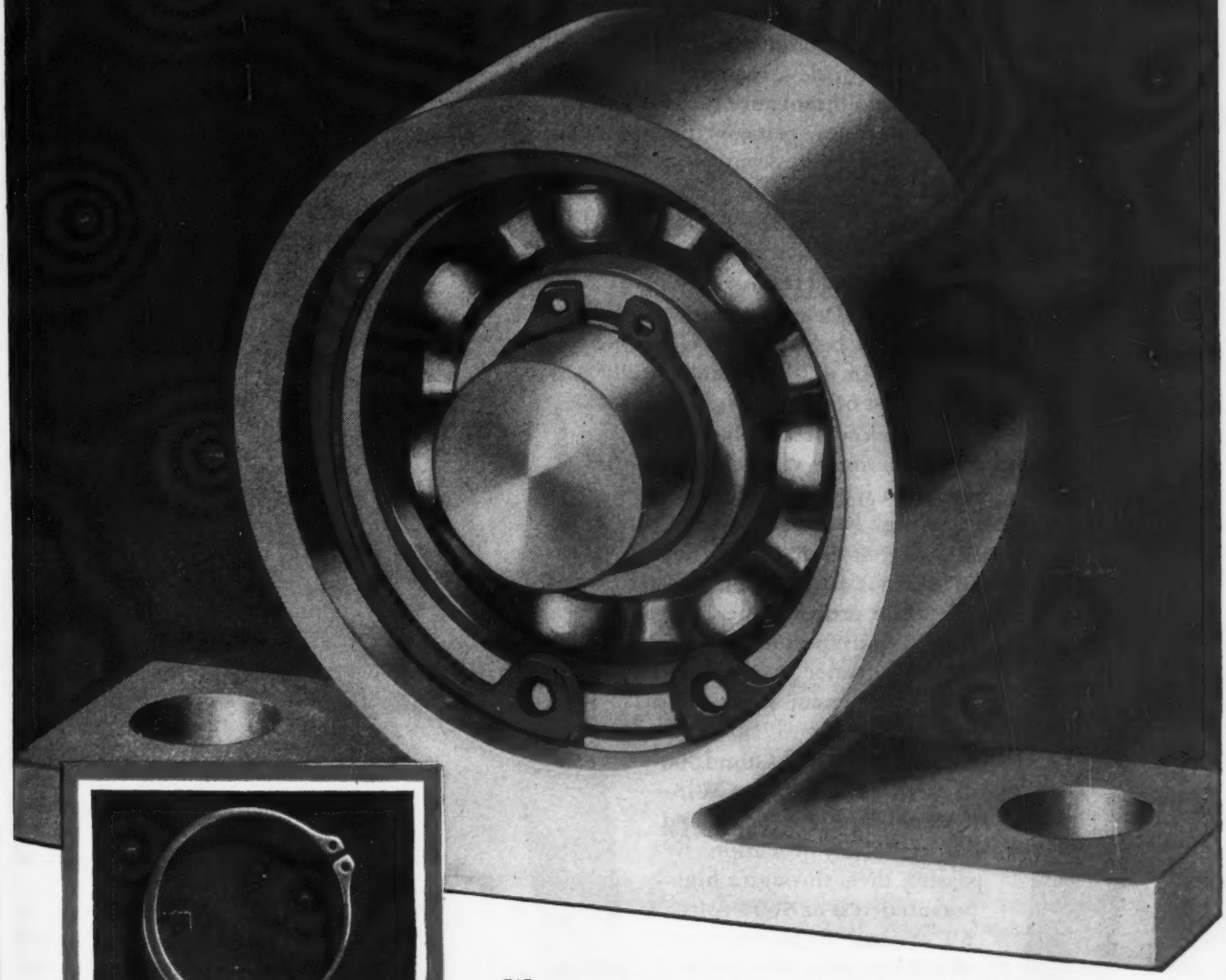
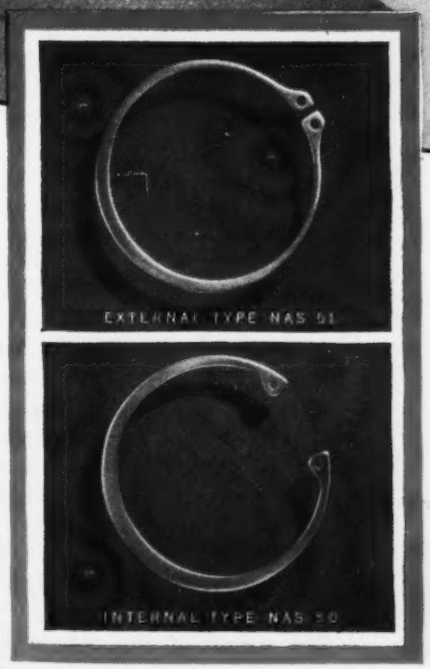
U. S. PATENT RE. 18,144





Waldes Truarc expands or contracts without distortion and without permanent set, fitting tight all around the groove. It offers important advantages over shoulders, nuts, collars, etc., for all thrust-load fixings in shaft and housing applications. It saves space, weight, assembly time and machining costs. Waldes Truarc presents a significant advance in retaining rings, well worth your thorough investigation. We will gladly furnish samples and full data for tests, upon request.

- Internal type National Aircraft Standard 50.
- External type National Aircraft Standard 51.

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DELTABESTON
RADIO HOOK-UP WIRES
Designed For Electronic Devices

G-E Deltabeston Radio Hook-up Wires are designed specially for producers of electronic equipment. These wires are used extensively for airborne and ground radio communications, as well as other closely associated applications. G-E Deltabeston is constructed to provide excellent protection against flame, heat, cold, moisture, fungi and most corrosive vapors. All low-voltage types are fully approved under the Joint Army-Navy Specifications JAN-C-76.

Here are only a few of the many physical and electrical tests to which we subject Deltabeston to help provide trouble-free service:

Heat Resistance Test Deltabeston is wrapped around a mandrel, baked at 121 C for one hour, immersed in water and successfully withstands a test of 2000 volts.

Heat and Humidity Test Deltabeston is tested to determine the suitability of the insulation when subjected to conditions of high heat and moisture.

Cold Bend Test Deltabeston is subjected to minus 40 C for at least four hours. While at this temperature, it is bent around specified mandrels immersed in water where it withstands a minimum potential of 2000 volts.

Dielectric Test Deltabeston 1000-volt rms Radio Hook-up Wires are tested for high quality and uniformity of insulation by passing them through a high potential test at 5000 volts, 60 cycles. Deltabeston Hook-up Wire 3600-volt rms is spark tested at 10,000 volts.

For complete information, write to Section Y956-119, Appliance and Merchandise Department, General Electric Co., Bridgeport, Conn. All Deltabeston Wires and Cables are distributed nationally by Graybar Electric Co., General Electric Supply Corp. and other G-E Merchandise Distributors.

BUY WAR BONDS AND KEEP THEM

GENERAL ELECTRIC

means an extra filament transformer. Then, because the voltage across the input filter capacitor is often too high, it must be limited by R_1. If we want only a hundred volts or less of bias (say for 2A3's), we must have an additional dropping resistor R_2. This requires two power resistors, which means power wasted and a lot of heat dissipated.

The circuit of Fig. 2A, uses a shunt diode with the cathode grounded, so there is no problem of

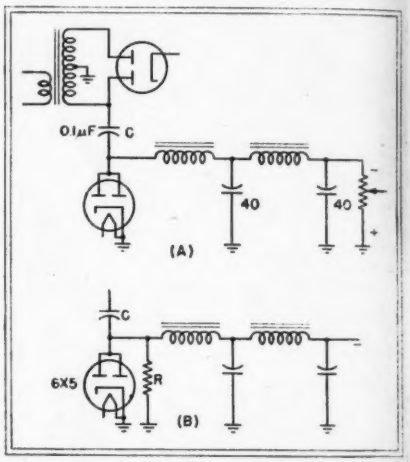
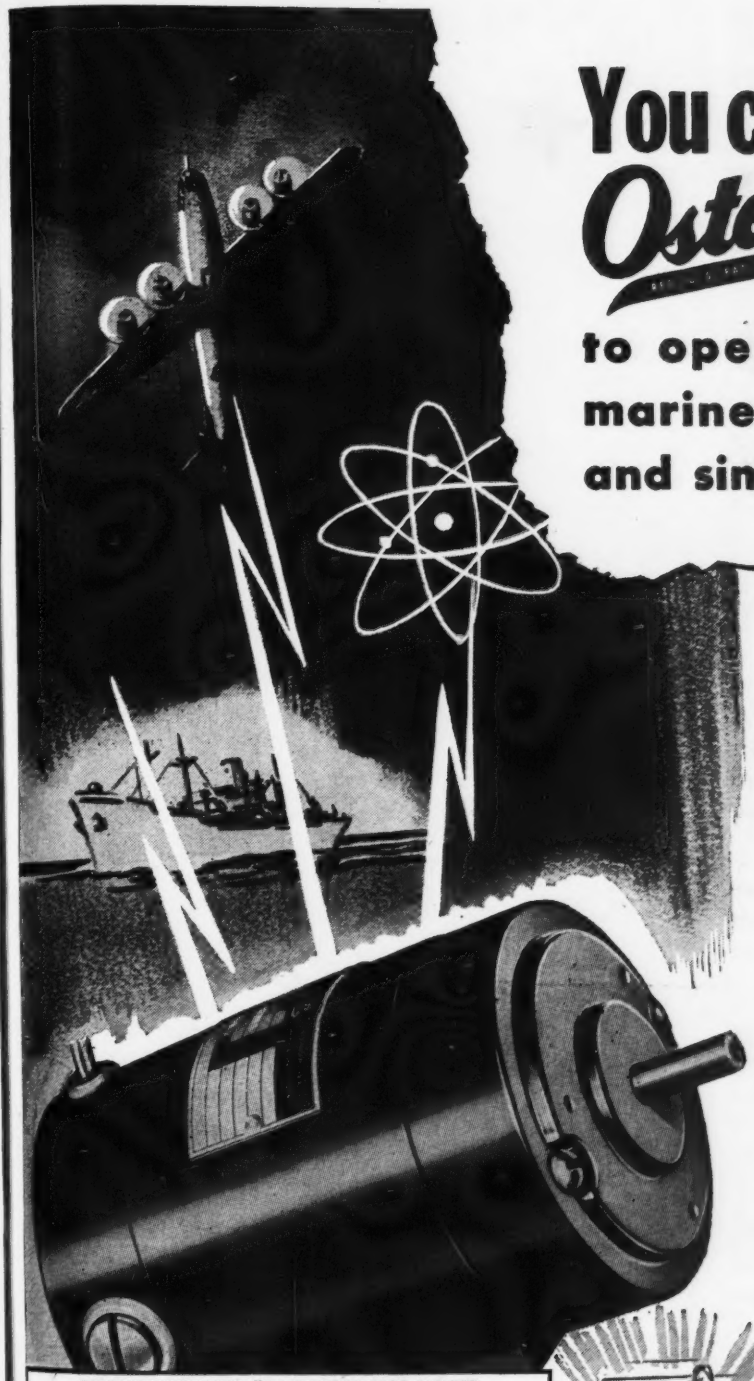


Fig. 2—At *A* is a circuit for obtaining bias with a shunt diode. Capacitor C acts in conjunction with the load resistor to form a voltage divider. When only one bias voltage is needed, the circuit shown at B may be used

heater supply. The load is tied directly across the output filter capacitor and the dropping resistor is eliminated. The capacitors work at low voltage so their rating need not be high. The entire voltage drop is accomplished in the input capacitor C with, obviously no loss of power and no heat.

For an output of 100 volts at about eight milliamperes (to 2A3 grid-voltage control potentiometers or other load), C will be of the order of 0.1 μf. It will vary with line frequency and load requirements. If separate bias voltages are not required, the load (which is merely a grid return to ground) may be removed from the output capacitor and placed across the diode as shown in the alternate circuit of Fig. 2B. The grid returns are connected to the filter output. Since the filter is then unloaded, this will provide even better filtering.

The circuit of Fig. 2A, with the



You can rely on this *Oster* Blower Motor

to operate dependably in marine, aircraft, electronic, and similar applications . . .

In planning your post-war product, it is well to remember the design and operating advantages of this Oster blower motor. Although it has been especially designed for use in the marine, aircraft, and electronic fields, it may have qualities that fit your particular product. Check these features:

Housing: Die cast, zinc field housing and aluminum end brackets. Totally enclosed.

Finish: Black baked enamel.

Weight: 5 lbs.

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Windings and Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

Mounting: Available with either base mounting or machined pads.

Brushes: Metal graphite or electro-graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

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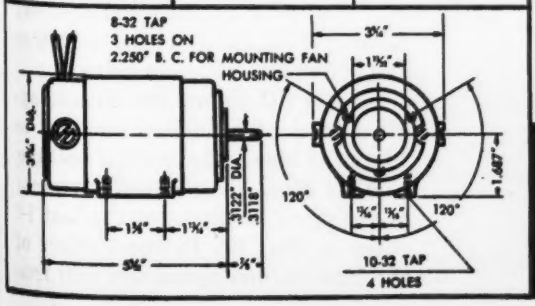
PERFORMANCE WITH #3 L-R TURBO TYPE BLOWER		
Type	F-9A-3	F-9-4S
Voltage	115 A.C. 60 CYC.	27 D.C.
Amps. Input	2.7	7
R.P.M.	6000	6000
Rotation	Clockwise Drive End	Clockwise Drive End
Starting Torque in % of F. L. Torque	200	300 — 400



You can recommend Oster Motors with full assurance that they will live up to the world-wide reputation of pre-war Oster appliances, Oster-powered.

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The makers of temperature responsive controls—now playing an indispensable part in winning the war—will take an even greater part in building a better postwar world.

The demands of Industry for devices to control processes, to assure exact temperatures, to protect machines or motors against heat or stress—

The demands of Transportation for proper temperatures in both passenger cars and in freight-cars carrying perishable goods, as well as for giving the "green light" to over 500,000 miles of rails, 24 hours a day—

The similar demands of aviation, and even of our private automobiles, in which there are now more than 16 applications of bimetal control; and the insistent demands of our homes for more and better automatic home appliances—

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W.M. CHACE CO.

Manufacturers of

Thermostatic Bimetals and Special Alloys

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values shown, delivered 100 volts across four 5000-ohm potentiometers connected in parallel to supply the grids of push-pull parallel 2A3's. The ripple level was 0.01 volt.

Practical Circuit

An adaptation of this circuit is shown in Fig. 3A. This is intended as a source of 3 volts bias for r-f and i-f stages of deluxe receivers, thereby saving cathode bypass capacitors and resistors, and the space they occupy. This circuit will

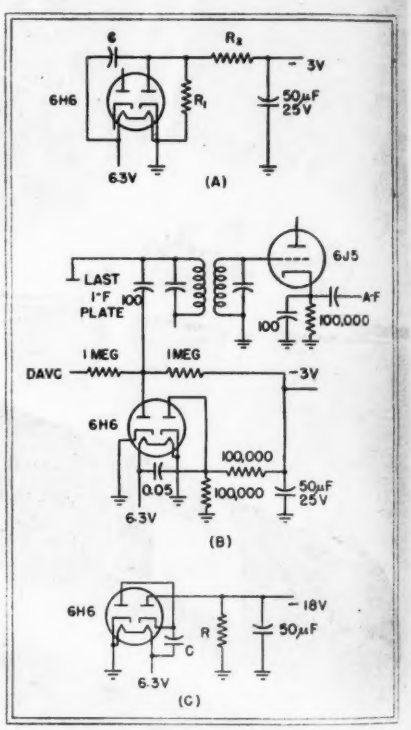

Fig. 3—Bias voltage for r-f and i-f stages is obtained from the simple circuits at A. By supplying the rectifier plate from the heater line, up to nine volts of bias is provided. B is for use in an high-fidelity receiver. Bias for beam-power tubes is provided by the circuit at C, a half-wave voltage doubler whose output is 18 volts at an input of 6.3 volts rms

deliver up to 9 volts from a 6.3-volt heater line, depending upon C and R_1. The value of the filter resistor R_2 may be of the order of 50,000 or 100,000 ohms. It is not critical.

Figure 3B shows the circuit applied in a high-fidelity receiver as source of bias and avc delay voltage. The avc diode (also wired in shunt) is fed from the plate of the last i-f stage so that the flywheel effect of the transformer secondary will iron

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Thordarson's tradition of quality provides the underlying reason for its past half-century of progressive leadership in the specialized manufacture of dependable transformers, components and other electronic devices. This same tradition, upheld through every phase of *Thordarson* design, engineering and manufacturing is your guarantee of the finest transformers for requirements of Tomorrow . . . and years to come. With confidence . . . gained by this ability to produce quality merchandise and coupled with novel sales policies . . . *Thordarson* looks forward to supplying the expanding demands of the radio and electronic industries.

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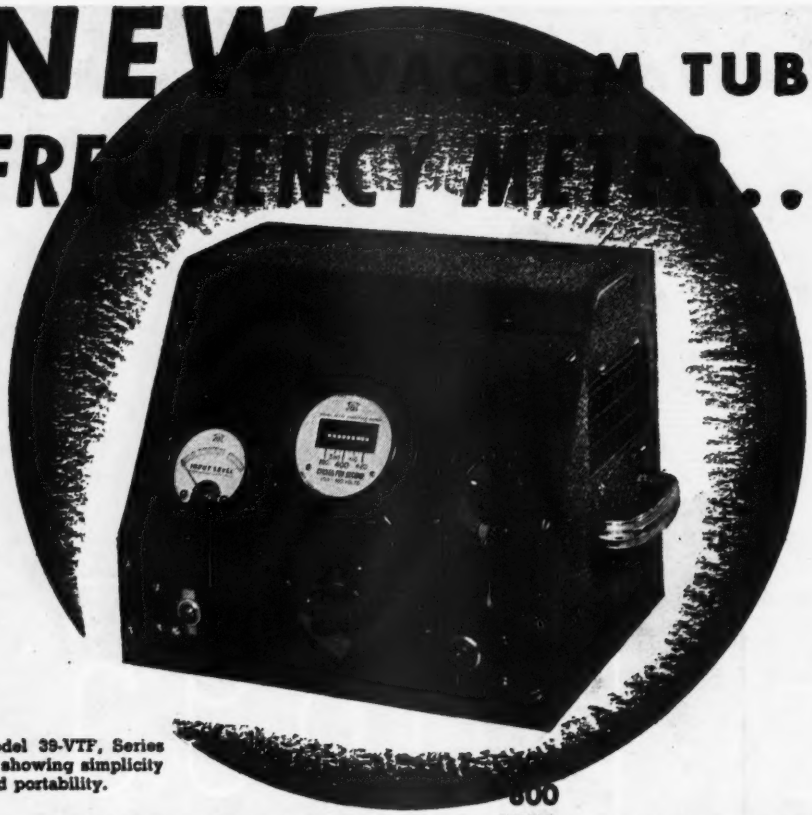
NEW VACUUM TUBE FREQUENCY METER . . .



Model 39-VTF, Series A, showing simplicity and portability.

. . . FOR FREQUENCIES IN 600 1200 1600 2400 3600 CYCLE BANDS

MODEL 39-VTF, Series A, a new development of J-B-T engineers, measures frequencies in six specific bands with accuracy of ± 0.25% of the frequency being measured, and with sufficient amplitude to be easily read.

Vacuum tube multivibrator circuits divide the incoming frequency by 1, 2, 3, 4, 6 or 9, depending on the position of the multiplier switch, and show the result on the time-tested, standard 400 cycle meter.

Regular line current is used for power supply, permitting an input sensitivity of 500,000 ohms. Response is not affected by irregular wave form, nor by harmonic content of unknown frequencies of less than 10% or 15% . . . and input control permits use from 100 to 350 volts.

The result is an instrument of high accuracy and high stability with permanent calibration . . . especially useful for checking audio oscillators, frequency converters, radar equipment, and for standardizing less accurate frequency measuring units.

Check These Points

- **EXTREME ACCURACY** ... within ± 0.25% of frequency being measured.
- **PERMANENT ACCURACY** . . . no further calibration or standardization required at any time.
- **STABILITY** ... no temperature drift after initial 30 second warm-up.
- **BURN-OUT PROOF** . . . no protection needed against accidental above-range frequencies.
- **SENSITIVITY** . . . 500,000 ohms.
- **SIMPLICITY** ... uses standard tubes.
- **POSITIVE SWITCHING** . . . built-in switch is J-B-T's own rugged, coin-silver plated instrument switch, as supplied for high quality testers.

New Booklet . . . just off press, illustrates other types of J-B-T Vibrating Reed Frequency Meters. Ask for Bulletin VF-43-1C.

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out the peak shunting due to the diode and hence eliminate distortion from this source. The detector is of the infinite-impedance type and will not load the secondary and so reduce the *Q*. The cathodes throughout the set may be grounded.

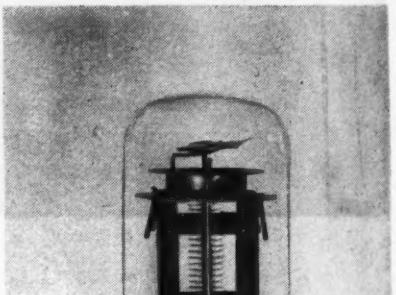
Figure 3C shows a half-wave voltage doubler supplied from the 6.3-volt heater line that will provide up to 18 volts (again depending on *C* and *R*) to pentode and beam-power tube grids for fixed-bias operation.

• • •

Popular Radar Tube Made in America

THE TUBE THAT had a wider use abroad in radar than all other receiving types combined is known as the VR-91. Because of its performance at uhf, it was used in 284 types of British equipment.

During the peak of the air war over England, large quantities of the tube were greatly needed yet time could not be taken to develop new methods for its manufacture in high-speed production. After American manufacturers were



Receiving tube type VR-91, used in 284 types of British radar equipment

appealed to, Sylvania Electric Products was granted permission to modify the design for high-speed production.

Seventeen major changes were made in the British design, including grids, micas, getter, connectors, mount support, shield, and methods of testing. The diameter of the

CATHODE RAY TUBES THAT MEET EXACTING SPECIFICATIONS

NORTH AMERICAN PHILIPS is one of the few manufacturers of electronic tubes endowed with the skill and experience required for the mass production of the 5JP1 and similar cathode ray tubes.

The deflection-plate terminals of these tubes are brought out at the neck of the glass envelope to provide higher insulation and lower lead capacitance at very high frequencies.

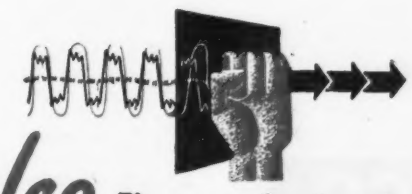
In the manufacturing procedure the tubes are cracked at the neck, the deflection-plate leads bent out, and the envelope sections rejoined on a glass-sealing lathe, as illustrated. During this operation the tubes are maintained at a high temperature to prevent the formation of water vapor on the fluorescent screens.

The ability to produce, in volume, NORELCO cathode ray tubes that meet exacting specifications is the result of experience gained by an organization with a background of over half a century of research and development in the electrical field.

The facilities which North American Philips has applied to the manufacture of electronic tubes in wartime will be immediately available for the post-war production of cathode ray tubes for direct viewing and projection television.

Write today for interesting booklet on "How and Why Cathode-Ray Tubes Work."

When in New York, be sure to visit our Industrial Electronics Showroom.



Norelco Reg. U. S. Pat. Off. *Electronic Products by*

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1. **MURDOCK "precisioneering" brings the message through naturally—without strain, chatter or distortion.**
2. **MURDOCK'S "solid-built" durable construction protects the fine, sensitive adjustments from shock.**
3. **MURDOCK'S "air-cushioned" phones provide long listening without head discomfort.**
4. **MURDOCK'S ventilation means cool comfort—prevents condensation.**
5. **MURDOCK'S two-way adjustment controls position for smoother performance.**

Murdock's entire factory is now working for Uncle Sam. But as soon as victory is won, Murdock men, machines and materials will resume their peacetime position as a leading manufacturer of radio phones, telephone and electrical specialties for civilian use.

Plan for that peace now. Write today for new catalog.

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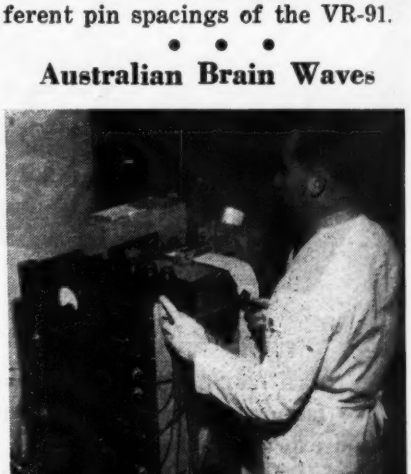
No. 1 grid wire was changed from one mil to 2½ mils, which increased the strength nearly forty times. The grid geometry was also changed. The No. 2 grid was changed from oval to hexagonal for greater strength and speed of manufacture. The two-piece plate was changed to one-piece wrap-around. This increased strength and stepped up the manufacturing speed four times. To save on critical materials, the shield and plate were changed from carbonized nickel to carbonized plain steel and nickel-plated steel.

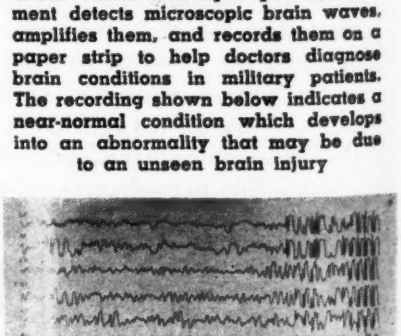
The VR-91 is a nine-pin tube with a larger base and pin circle diameter than the lock-in type. A practical duplicate of the British base construction was worked out to fit the Sylvania standard bulb, and a new set of molds was built to take the smaller size pins and different pin spacings of the VR-91.

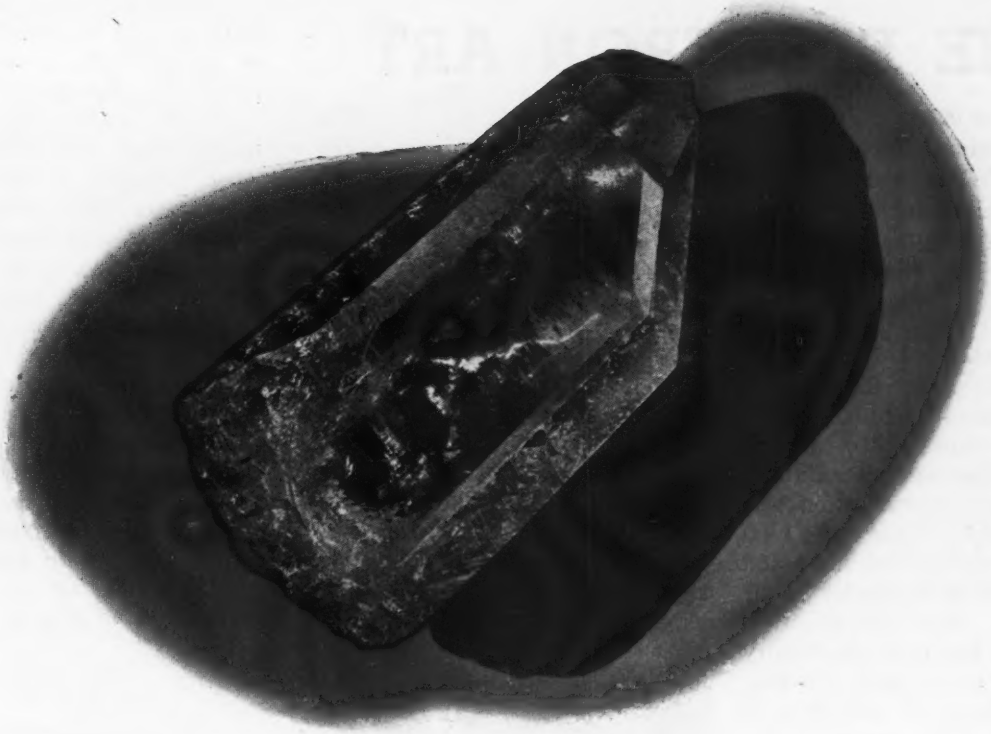
• • •

Australian Brain Waves



The only electro-encephalograph in Australia is shown in operation at an RAAF center near Sydney. The instrument detects microscopic brain waves, amplifies them, and records them on a paper strip to help doctors diagnose brain conditions in military patients. The recording shown below indicates a near-normal condition which develops into an abnormality that may be due to an unseen brain injury





Here all similarity ends...

from this point on, it's craftsmanship!

In one important respect there is a striking similarity between the millions of Bliley crystals which we now produce and the mere handful of custom made units that constituted our annual production when radio was still young.

In those early days of radio, when each quartz crystal was painstakingly cut and ground by hand, a tradition was born. It was a tradition of craftsmanship that has grown with the years—a tradition that Bliley engineers have successfully translated into the more intricate techniques of volume production.

Etched crystals are an outstanding discovery and development of Bliley research engineers. This technique, by means of which crystals are finished to frequency by acid action rather than abrasive action, was an established part of Bliley production long before Pearl Harbor. It has since proven to be an essential element in the manufacture of crystals that have the dependable characteristics necessary for military communication in global warfare.

We have been called upon to solve some knotty problems. But that is nothing new at Bliley. It has been our habit to parallel new developments in radio with the right crystal for each application.

Things will be different soon. Peacetime projects will again come first. But our engineers and craftsmen will be ready, as always, with the right answer to your requirements. Don't fail to include Bliley crystals in the component specifications for your peacetime equipment.

Do more than before...:
buy **extra** War Bonds

BLILEY ELECTRIC COMPANY UNION STATION BUILDING · ERIE, PENN.

THE ELECTRON ART

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Facts About Atomic Power*

THE PRACTICAL MAN in engineering is usually somewhat skeptical of the endeavors of his brothers in the pure sciences. To him the problem of designing and maintaining a modern communication system, for example, is far more vital than the knowledge that mass and energy are different aspects of the same thing. But the practical engineer who has read the history of technology knows that the theoretical postulates of science may turn out to be of the greatest practical importance. Knowledge pursued for its own sake has time and again declared a big dividend.

An excellent example of such corporate finance in the scientific world is now before the public eye, so much so in fact that the story appeared on the front page of the *New York Times*—at a time when the ordinary affairs of men have been consistently relegated to the inside pages. The story is the isolation of the isotope of uranium whose atomic weight is 235 and whose symbol is U^{235}.

U^{235} appears to be the first true atomic fuel discovered, and although its practical importance in the affairs of men at present is precisely nil, its potentialities are sufficient to fire the imagination of anyone whose background permits them to understand the facts in the case. The readers of *Electronics* fall in this class, hence your editors have sought out the factual references in the matter, and have attempted to separate the actualities from the guesswork and the wishful thinking.

What Is an Atomic Fuel?

It need hardly be said that modern technology depends upon sources of power, and that sources of power depend on fuel, either directly or indirectly. The fuels thus far available to industry have been in the *chemical* class. Coal and oil, for example, are useful to us because they are unstable chemical substances which can be ignited and which thereafter will continue to furnish heat until they are consumed, provided they are kept in a suitable burner or furnace. The burning process in ordinary fuel is essentially a release of chemical energy which accompanies the reorganization of the molecules in the fuel. Thus the hydrocarbon molecules of coal, when burned, become separated into water, free carbon, carbon dioxide, ash and other combustion products. The energy freed in the process results from the reshuffling of the atoms and the outer electrons of the atoms concerned. The nucleus of each atom, however, remains unchanged.

For some time the physicists have known that an entirely different kind of fuel lies within the range of scientific discovery. That fuel is the *atomic* fuel, in which great amounts of energy can be liberated from within the nucleus

The "match" for atomic fuel. Neutrons generated in this huge cyclotron at Columbia University were used to irradiate the sample of U^{235} isolated at the University of Minnesota. The neutrons, slowed down by passage through paraffin, induce instability in the uranium atoms, causing them to explode with tremendous energy. Thereafter the uranium isotope, if available in sufficiently pure form, will maintain its own "combustion"

* Reprinted from ELECTRONICS, July 1940, p. 12.

Eastern Air Devices Announces

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MODEL J81 AXIAL FLOW BLOWER

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AIR DELIVERY (FREE AIR)
375 C.F.M. (NEMA CODE)
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400 cycles • 115 volts • 6500 RPM 50 watts input • 1.0 mfd. condenser required • starting torque 2.25 oz. in • 80% power factor • weight of unit 16 oz. Fan: 4 blade propeller type, 4-inch diameter.

We invite inquiry!

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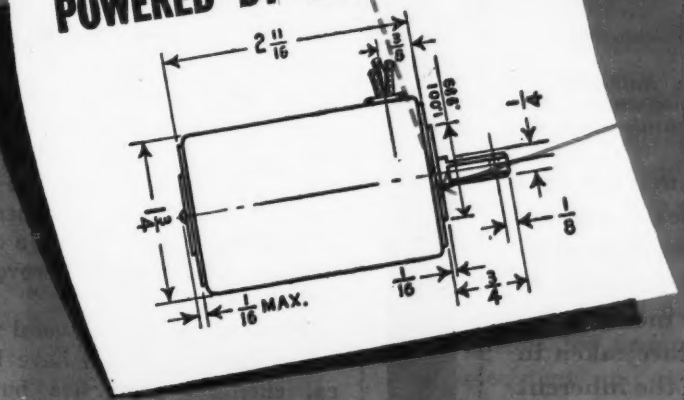

SINGLE PHASE
CAPACITOR INDUCTION MOTOR

1/50 H.P. • 400 cycles • 115 volts • 0.02 rated H.P. 6500 R.P.M. • Continuous duty as axial fan drive. Intermittent duty for general use • starting torque 2.25 oz. in • 80% power factor • 1.0 mfd. capacitor required • weight of unit 15 oz.

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with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!

ACCESSORIES
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Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multirange instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U. S. A.

of an atom. The nucleus, or central core of each atom, is composed of positive protons and neutral neutrons (possibly electrons also). The several positive charges are bound together in the nucleus very compactly, in direct contradiction to the electric law which states that charges of like sign repel each other. This anomaly has been explained on theoretical grounds, but its practical significance is that *if the law of electrical repulsion could be made to take effect within the nucleus,* the nucleus would fly apart with tremendous speed, and the associated energy could be transformed to heat in a manner very similar to that which makes the plate of a power tube glow red when bombarded by the electrons in the space current.

Such an atomic fuel, to be useful, must be capable of "supporting its own combustion," that is, once "ignited" it must continue to "burn" of itself until consumed. Moreover, it should be comparatively inert until ignited, and not too expensive in relation to the useful energy it can produce.

What is needed in an atomic fuel, then, is a nucleus which is normally stable, but which can be excited by some external means so that it becomes unstable. The heavier the atom, the more complicated its nucleus, the greater the number of positive charges it contains, and the greater its tendency toward instability. It is not surprising therefore that uranium, the heaviest element and having the highest positive charge on its nucleus, should prove suitable for the purpose.

Uranium exists in several forms, called isotopes, which have identical chemical properties but different atomic weights. The most prevalent isotope, of atomic weight 238, symbol U^{238}, is normally stable, but can be excited into instability if bombarded with neutrons of very high energy (energy such as would be imparted to a unit charge by passage through an electric potential of several million volts). Another isotopic form, the one of atomic weight 235, U^{235}, is very easily excited to instability by the action of neutrons of very

From Metal Fabrication to Finished Unit . . .

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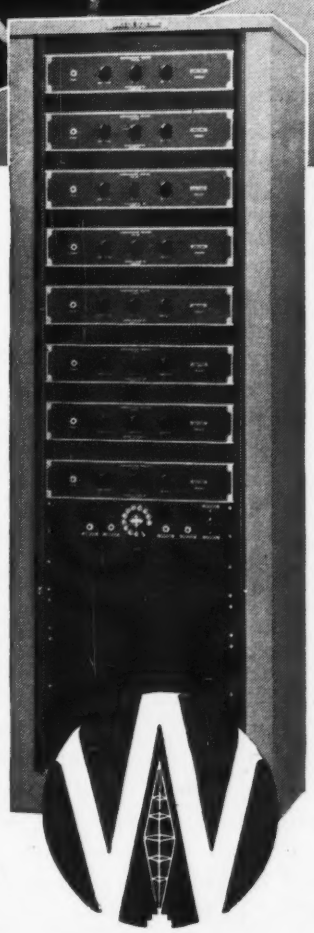

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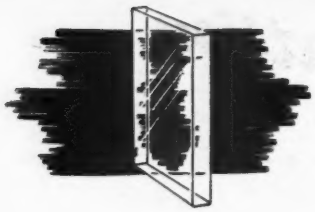

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low energy, corresponding to an electric potential of roughly 1/40 of a volt. Moreover, when the U^{235} nucleus flies apart, from to 2 to 3 neutrons are generated in the process. These neutrons may go off in turn to "set off" and cause the disruption of other nearby U^{235} nuclei. Thus the conditions for a "chain reaction" are available, and the atomic combustion may be made self-supporting. But the chain reaction cannot occur if the atoms of U^{235} are diluted by stable atoms of uranium such as U^{238}, any more than pulverised coal can be made to burn if it is mixed with a high percentage of sand or some other non-combustible material. Hence the need to obtain U^{235} in pure, or nearly pure, form.

In natural uranium, the two principal constituents are U^{238} and U^{235}, which occur in the ratio to 139 U^{238} atoms to every U^{235} atom. Thus the active component U^{235} is so heavily diluted by the inactive component that the atomic combustion cannot be self-supporting until the U^{235} is separated from the combination. U^{238} and U^{235} are identical chemically, hence cannot be separated by chemical methods. The only difference on which separation can be accomplished, so far as is now known, is the difference in their masses, and this difference is only 3 parts in 235, or less than two percent. Here, then, is the rub. Can a simple and economical means be found to separate U^{235} from U^{238}? If so, a new fuel is available which has the virtue of being highly concentrated, and which *may* compete with coal or oil on a price basis, *provided* the several economic and technical questions are satisfactorily answered.

A very interesting analysis of the problem has been worked out by Roberts and Kuper.[1] They point out that U^{235} supplies about 200 million electron volts of energy per atom, whereas coal supplies 4 electron volts of energy per atom. The ratio of energy is then 50,000,000-to-1 on an atom basis. By a weight basis, if we compare coal with uranium oxide as raw materials, this ratio must be divided by the relative concentration of U^{235}, 1 in 139, and by 20 to account

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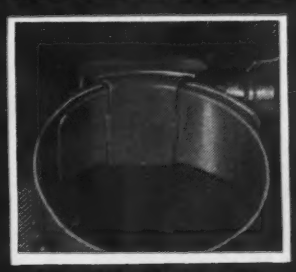

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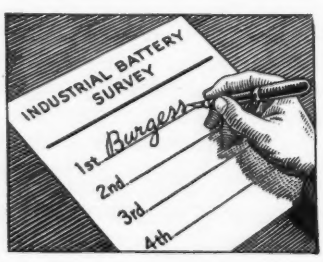

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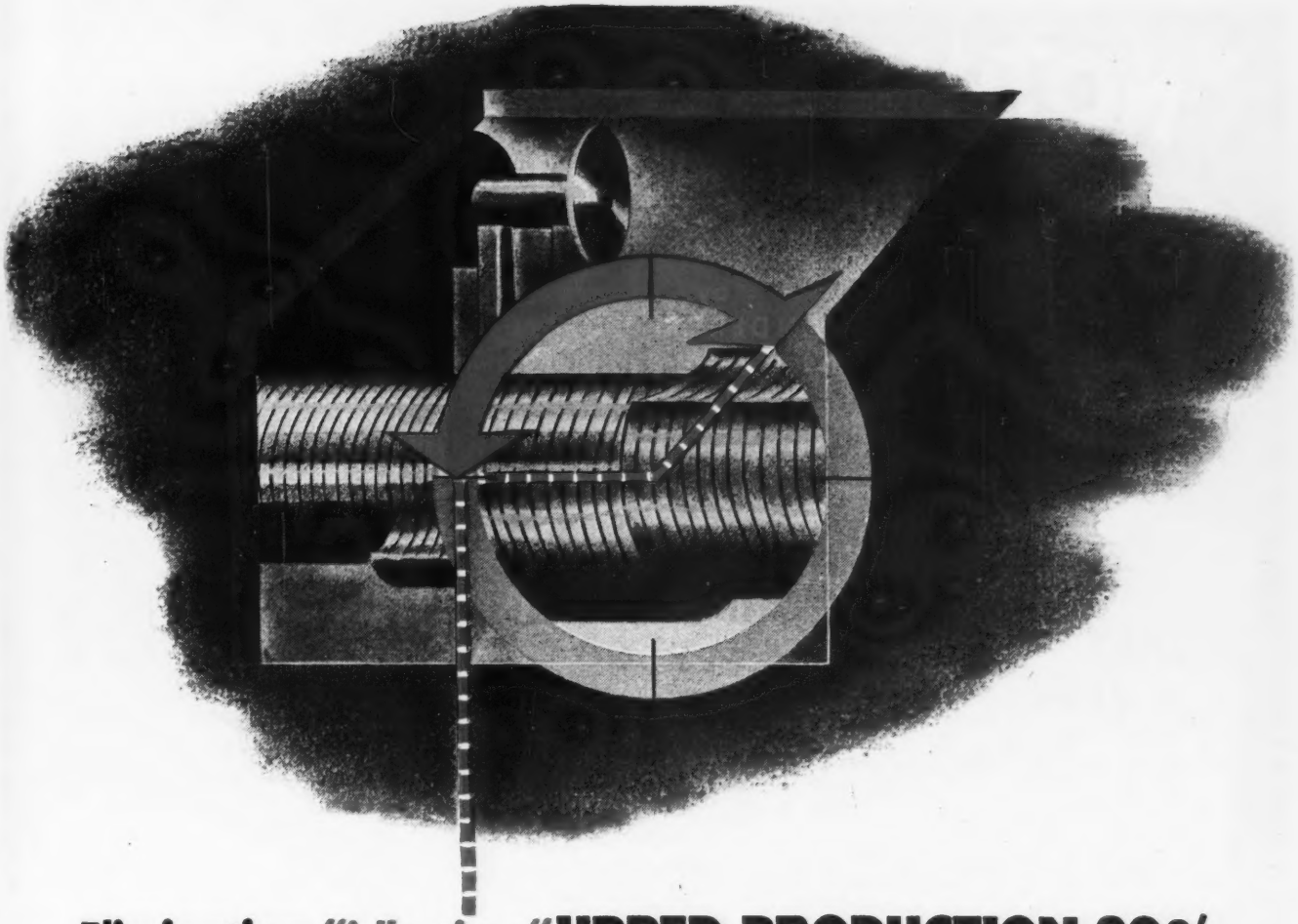
for the difference in the molecular weights. This gives U^{235} an advantage over coal of about 17,000-to-1, on a weight basis, considering the raw materials. What about cost? Uranium oxide costs about $2 per pound or $4000 per ton, whereas coal costs but a few dollars per ton. Thus the cost of energy from coal turns out to be about 8 or 9 times as great as the cost of an equivalent amount of energy from U^{235}, provided that the cost of extracting the U^{235} from the uranium oxide is completely disregarded. No account is taken moreover, of the available supplies of uranium compared with coal, and the trend of the costs of uranium ore which will go up as the supply dwindles, or go down if the supply lasts and the mining methods improve.

The crux of the matter seems to be the cost of extracting U^{235} from U^{238}. If a method can be found which costs less than 1/8th or 1/9th the cost of coal for an equivalent energy production, then U^{235} is in direct competition with coal. Thus far, however, any such extraction method is only a dream. The grim reality is that U^{235} costs much more to extract than it is worth as an energy source. No one knows when an economical process may be found. The whole world is looking for it, but it may never come to light. If so, U^{235} is just a flash in the scientific pan, so far as atomic power is concerned.

There remains however one definite utility in the study of U^{235} which may be realized much more immediately. This possibility lies in the "ash" which remains when U^{235} has been "burned." When the U^{235} nucleus splits apart it forms two new nuclei of comparable weight (roughly 100 and 140 units of atomic weight each). The position of these nuclei in the atomic table approximates that of barium and the nearby elements. Actually, some 20 different types of atoms have been identified as the "combustion products" of U^{235}, and more will no doubt be found. These atoms, moreover, are artificially radioactive. Thus a whole new series of radioactive elements may be produced in quantity and very cheaply. The prospect of



Eliminating "idle time" UPPED PRODUCTION 30%

On cylinder heads for radial aircraft engines, dozens of cooling fins are required. To handle this intricate cutting job automatically, a machine tool manufacturer designed a special fin-milling machine using conventional constant-speed drive to rotate the cylinder head.

But preliminary tests showed that, because of the varying depths of the cuts, production could be increased if an adjustable-speed drive was applied to rotate the workpiece. Due to irregular shape of the workpiece, the milling cutter was usually under light load. At certain points in the cycle, it was out of contact with the metal altogether.

Westinghouse engineers were called in for consultation. Their recommendation: application of the Mot-o-trol — an electronic adjustable-speed drive with accurate load control characteristics. Through its application, rotating speed of the workpiece is greatly increased over the light-load sections—thus eliminating "idle time". Full load is maintained on the cutter regardless of the contour being cut. By these improvements, *production was stepped up as much as 30%.*

This is typical of the modernizing possibilities with electronic equipment in countless industrial tasks. Your nearest Westinghouse office is ready now to supply helpful assistance and information on electronic applications for your industry. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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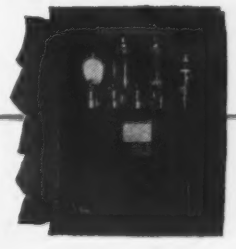

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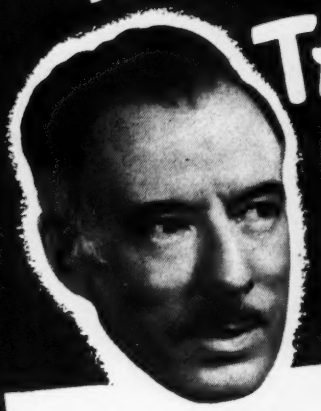
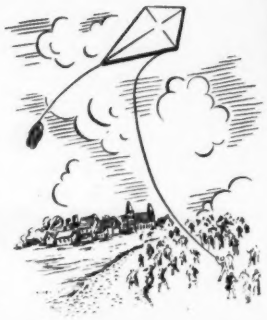


by
ALEXANDER McQUEEN
Famous Radio Feature
Commentator

A Monarch Fact Story

THEY TESTED THE AIR WITH A PIECE OF RAW BEEF . . .

In London, about 1730, when doctors wanted to test the air for purity, they would send up a piece of beef on the tail of a kite. After 10 minutes the beef would be pulled down, and if it was not spoiled the air was considered healthful. Actually this was NOT a scientific test, because the composition of the upper air is almost surely different from that of the air at ground level.



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almost unlimited amounts of cheap radioactive materials of various characteristics, is so attractive to the fields of biology, medicine, chemistry, and physics that it justifies an intense study of U^{235} even if there were no larger implications involved from the power standpoint.

Two Germans, Hahn and Strassman started the ball rolling when they found, something over a year ago that ordinary uranium, consisting of a combination of isotopes, could be bombarded by neutrons and would supply atoms of barium as a result. Similar transformations from one type of atom to another had been known for years, but the distinguishing feature of this discovery was the fact that the original atom and the resultant atoms were very far apart in atomic weight. This meant that a very great amount of energy was given off in the process of disrupting the uranium atoms. No clue was given as to the actual seat of the disruption, that is, whether it resided in U^{238}, U^{234}, U^{235} or some other isotope. Measurements soon showed that the energy released was indeed enormous, some 200 million equivalent electron volts in each nuclear explosion. The clue to the atomic fuel had been found and the rush was on to identify and to abstract it in as pure a form as possible.

No one knows how many workers in physical laboratories addressed themselves to these problems in the ensuing months, but it must have been many hundreds. Much of the work is veiled in political secrecy, hence no one knows where the credit will eventually go, but certainly it will belong to dozens of men rather than to any single individual. Be that as it may, Professor Alfred O. Nier of the University of Minnesota was the first to announce the separation of U^{235} from U^{238} in a sufficient amount to permit further investigation. He did so by electronic means. A piece of solid uranium bromide was heated in a small box in vacuum, and the UBr^4 vapor thereby produced was bombarded by an electron beam of about 0.1 ma. Positive ions formed by collision of the

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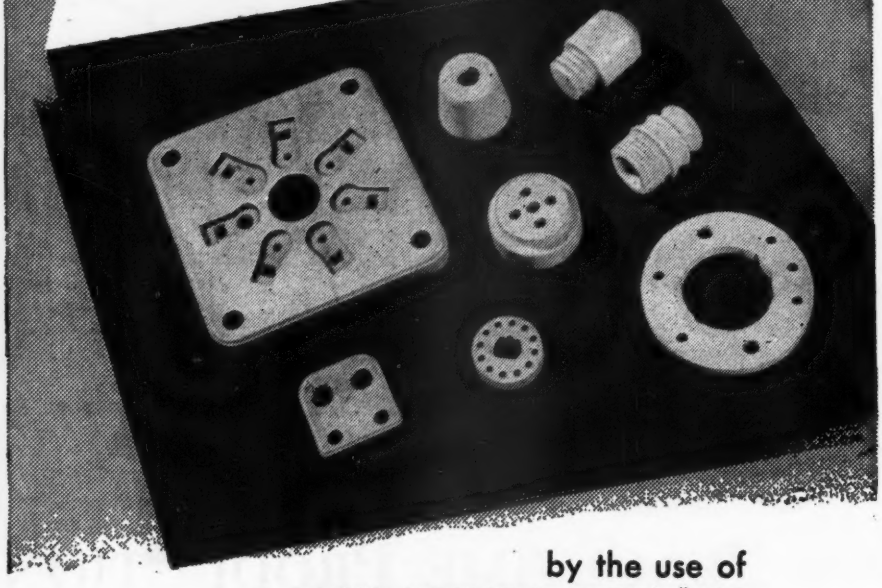

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electrons with the UBr^4 atoms were drawn through a slit, accelerated to about 1000 volts energy, then caused to move between the poles of a large electromagnet through a semicircular tube. This apparatus, a mass spectrograph, is used to separate atoms on the basis of weight, since the radius of the circular path pursued in the magnetic field by a charged particle depends on its mass. After passing through the semicircular tube, therefore, the heaviest atoms (U^{238}) were deflected least and the lightest (U^{234}) most. Nichrome plates were used to collect the separated streams of ions, which deposited as uranium atoms. In one run of 10 hours duration, 1.7×10^{-7} grams of U^{238} were deposited on one plate, and 1/139th as much of U^{235} (with small contamination of U^{234} also present) on the other. On another run 2.9×10^{-7} grams of U^{238} were deposited. These are truly infinitesimal amounts, and although the yield has since been increased by several hundred times, the isotope can only be said to be isolated, not made available in a practical sense.

The samples of U^{235} and U^{238} were then taken to Columbia University and bombarded with neutrons generated in the cyclotron in the Physics Laboratory by Booth, Dunning, and Grosse. The neutrons used were slowed down by passage through paraffin, since they are generated at too high a velocity by the cyclotron itself. In one run, only one fission (atomic disruption) in 100 minutes was noted with U^{238} and one every 2 minutes was noted with U^{235}. In a second run no fissions were noted within the experimental error with U^{238} and nearly one fission per minute was noted with U^{235}. This was the first experimental evidence reported[2] that U^{235} was in reality the seat of the atomic disruptions. The conclusion was reached that experiments with the possibility of a chain reaction should be confined to U^{235}. This report, in a letter in the *Physical Review*, was the signal for the newspaper reports which brought the matter to the attention of the public.

Physicists at the General Elec-

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This control unit was one of many pieces of equipment built for intercommunication in British airplanes.

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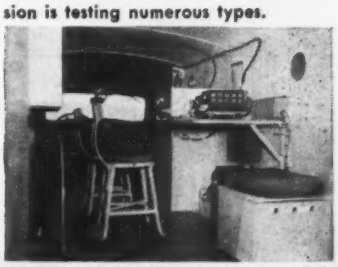

Interior of Pacific Division's mobile laboratory used in VHF communication development program.

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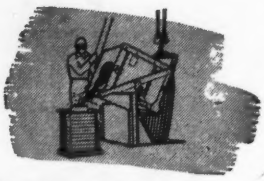

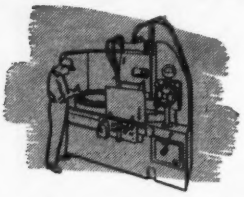

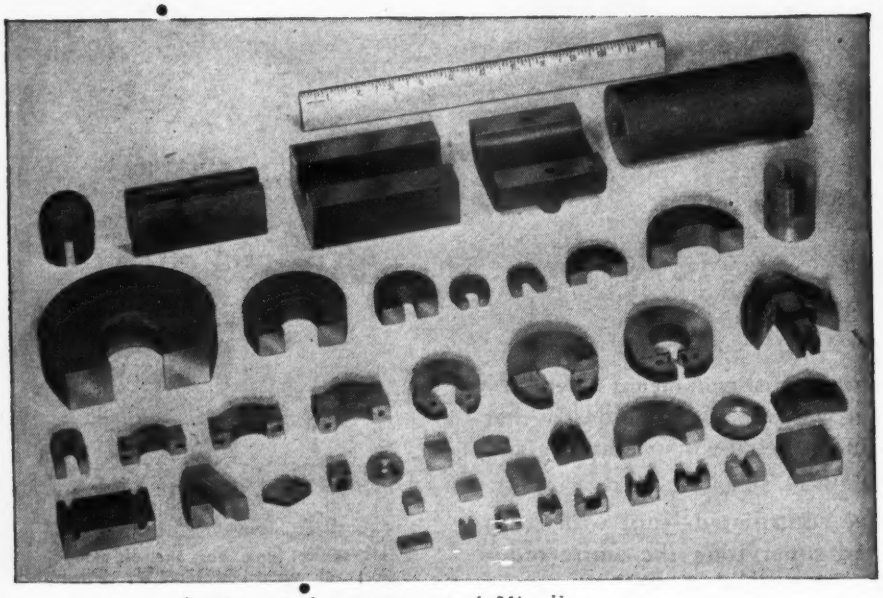

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SPECIALISTS IN THE MANUFACTURE OF ALNICO PERMANENT MAGNETS

tric Company, K. H. Kingdon and H. C. Pollock, have separated U^{235} fro[illegible] isotopes using a spectrograph. Uranium tetrachloride was heated, the vapor bombarded by electrons to form the uranium ions and the ions separated by a magnetic field. An illustration showing these men and their apparatus appeared in the June 1940 issue of ELECTRONICS, page 74.

The Attack on the Separation Problem

The means of separating U^{235} from U^{238} on a large scale have been under active consideration during the last year. Chapman as long ago as 1917 suggested that separation of isotopes by weight might be accomplished by means of "thermal diffusion", an effect which takes place when convection currents are induced in a gas composed of particles of different weight. Clusius and Dickel built an apparatus for the purpose, consisting of a heated wire running on the axis of a vertical tube containing the gas. Brewer and Bramley[3] used two concentric vertical tubes the inner one heated, the outer cooled, and passed gas through the space between the walls of the tubes. Furry, Jones and Onsager[4] of Harvard and Yale worked out the theory of the concentric tube device, but did not consider its use in the uranium problem. Recently Krasny-Ergen[5] of the Wenner-Grens Institute in Stockholm applied this theory to the uranium problem. He considered two concentric vertical tubes 10 meters (33 feet) long, the inner tube 4 cms in diameter, with 1.34 mm distance between the walls of the tube. The inner tube is heated uniformly to 393° C, the outer kept cool at 60° C. The space between the concentric tubes is filled with uranium fluoride, UF_6, at one atmosphere pressure. In such an apparatus the lighter U^{235} tends to collect at the top, where it is caught in a chamber. The calculations indicate that if the upper chamber were allowed to come to equilibrium and the gas drawn off (discontinuous operation), the concentration of U^{235} would increase

guide
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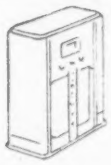

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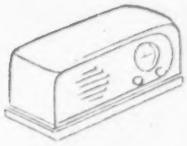

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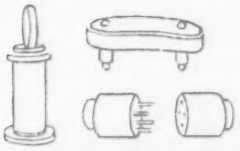

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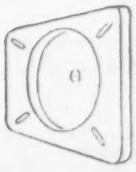

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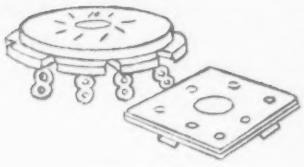

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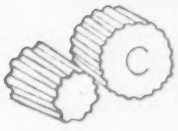

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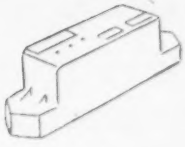

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	Tensile Strength	Impact Resistance	Heat Resistance	Dimensional Stability	Electrical Insulation	Color Range	Forms* Supplied	Molding** Methods
CEREX	good	good	to 230° F.	excellent	excellent	extensive	MC	I, C, E
FIBESTOS (cellulose acetates)	good to excellent	excellent	to 120—160° F.	fair to good	good	unlimited	MC, S, R, T	I, C, E
LUSTRON (polystyrene)	good	good	to 180° F.	excellent	excellent	unlimited	MC	I, C, E
NITRON (cellulose nitrates)	very good	excellent	to 140° F.	good	fair	unlimited	S, R, T	Special methods
RESIMENE (melamine-formaldehydes)	very good to excellent	good	to 210—380° F.	excellent	excellent	all but lightest colors	MC, IR	C, T
RESINOX (phenol-formaldehydes)	good to very good	good to excellent	to 230—450° F.	excellent	good to excellent	darker colors only	MC, IR	C, T
STYRAMIC HT (Polydichlorostyrene)	good	good	to 236° F.	excellent	the best	unlimited	MC	I, C, E
STYRAMIC (modified polystyrene)	good	good	to 184—187° F.	excellent	excellent	unlimited	MC	I, C, E
THALID	Completely reactive thermosetting resin for impression molding. Bonds glass cloth, fabric or paper into large panels or integrated forms in short curing cycles, with low temperatures and no pressures. Material is rigid, insoluble, fusible, highly resistant to abrasion, heat and water.							

*MC—molding compounds S—sheets R—rods T—tubes IR—industrial resins
**I—injection C—compression E—extrusion T—transfer, form of compression

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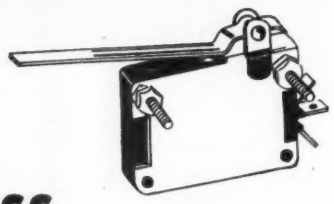

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6.7 times in 80 days. In other words, the percentage of U^{235} would be 4.8 per cent the amount of the U^{238}. Furthermore 42.8 milligrams of the gas mixture, 4.8 per cent of which would contain U^{235}, could be drawn off per day. If the gas were drawn off continuously only 28.3 milligrams having the same percentage of U^{235} or about 1 milligram of U^{235} per day would be obtained.

The cost of heating a 4 cm tube 33 feet long to 393° C and of keeping the other tube near it at 60° C was not estimated in this analysis, but it would appear to be considerable. Since a milligram of U^{235} has the power potential of 5,000 grams (11 pounds) of coal, the aparatus must be capable of being operated with considerably less than 11 pounds of coal for each milligram of U^{235} produced. Whether such a ratio would exist must remain a question to be settled by experiment. Krasny-Ergen and his colleague Grabe began construction of the tube just described, but the work had to be discontinued "because of the political situation".

The matter stands at present waiting for a conclusive demonstration that the chain reaction of U^{235} is indeed a reality, and this must await the separation of much more of the isotope than has been reported up to the present. When this event takes place, the important questions of the rate at which the energy is released, and the methods of controlling this rate (by dilution of the U^{235} with inert atoms, for example) will be determined. All these are scientific, not engineering, questions. The practical utilization of atomic power must wait the answer to such questions, and it must certainly await the development of economical methods of producing the new fuel before it can possibly enter into the industrial economy. In the meantime U^{235} is an isotope to watch. It may be going places.—D.G.F.

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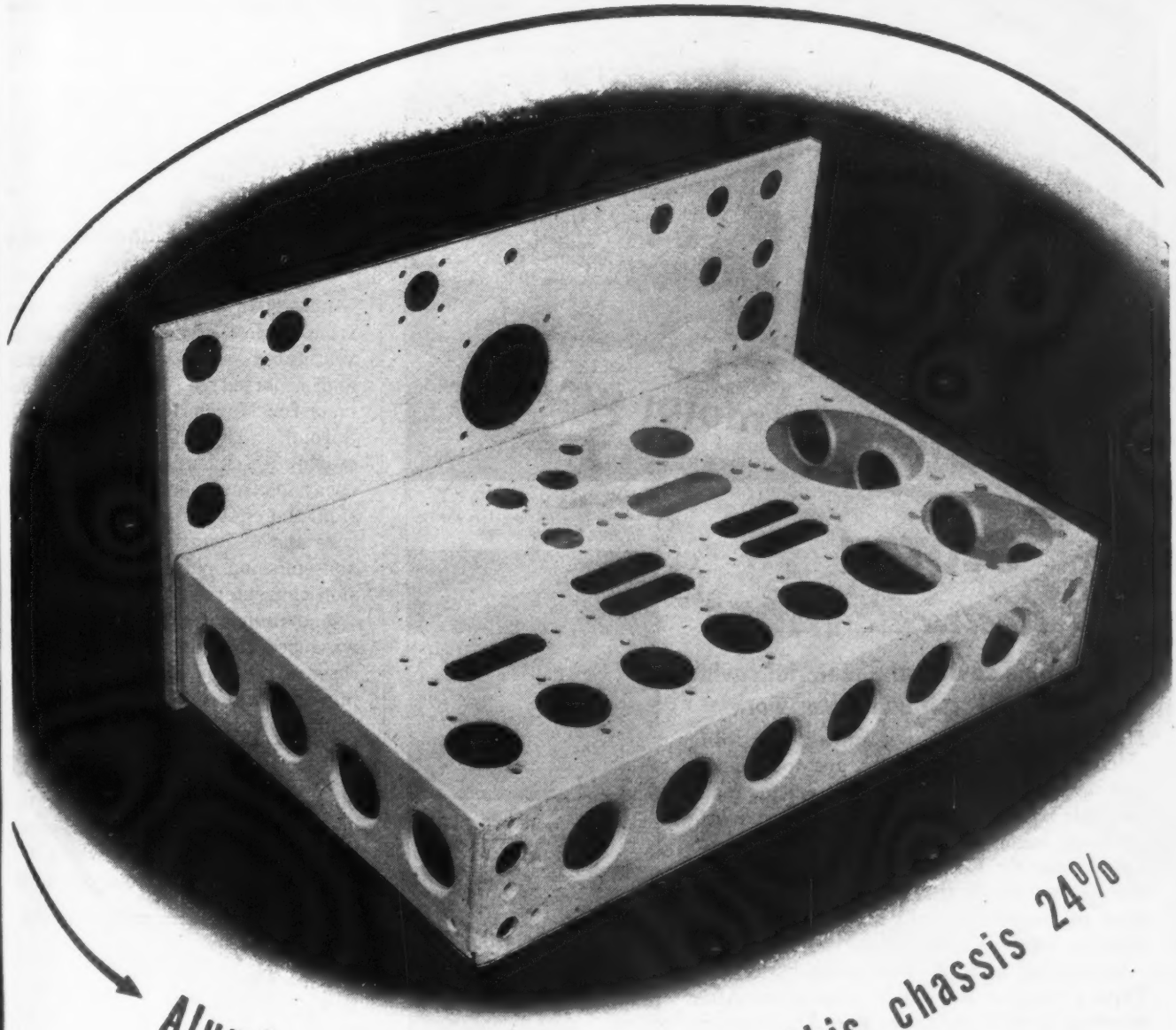
2. A. O. Nier, E. T. Booth, J. R. Dunning, A. V. Grosse, Letters to the Editor, *Physical*



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Photograph courtesy of Airadio, Incorporated, designers and manufacturers of radar and electronic test and communication equipment.

Before it was redesigned by Airadio, Incorporated, Stamford, Conn., this chassis for radar equipment weighed 17½ pounds. Made with Alcoa Aluminum the weight was reduced to 13 pounds and 5 ounces.

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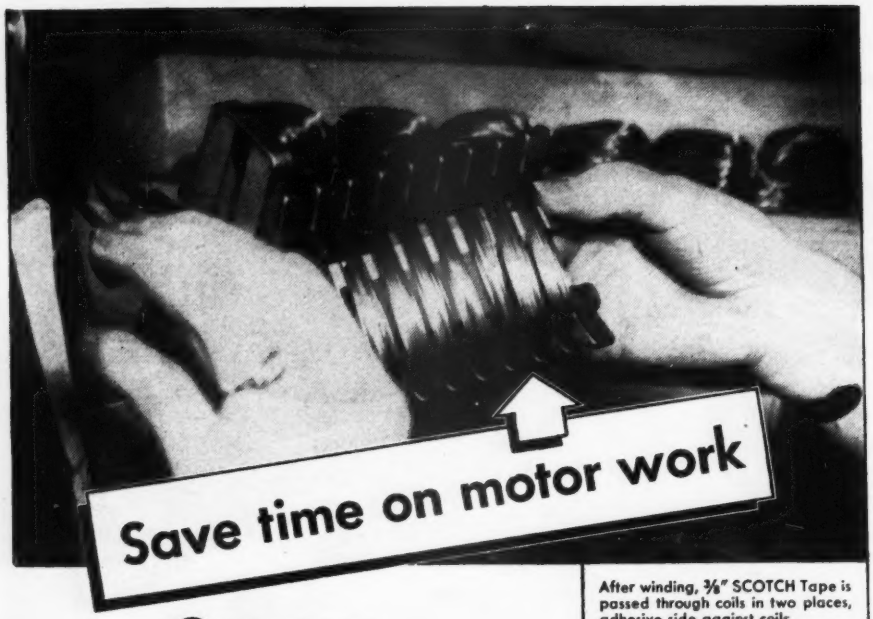

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Review, March 15, 1940 (Vol. 57, p. 546).
3. Brewer and Bramley, *Physical Review*, 55, 509A (1939).
4. Furry, Jones and Onsager, *Physical Review*, June 1, 1939 (Vol. 55, p. 1083).
5. W. Krasny-Ergen, Letter to the Editor, *Nature*, May 11, 1940.
See also an article in *Electrical Engineering*, February 1940, by Enrico Fermi.

• • •

Pulse Emission Characteristics of Oxide Cathodes

SHORT-TIME THERMIONIC emission from oxide-coated cathodes was investigated at Cornell University and reported in the *Physical Review* for March 1945 by Robert I. Sproull. The effect of cathode-coating thickness on emission, the decay characteristic during emission, the effect of cathode temperature and of length of emission and non-emission periods on the emission character were studied.

A cylindrical experimental diode was used for measurements. Representative types of cathode coating upon which measurements were made are given in the accompanying table. Cathode temperatures were observed with an optical pyrometer. Plate voltage for the diode was supplied by a rectangular wave generator in which the period and the relative duration of

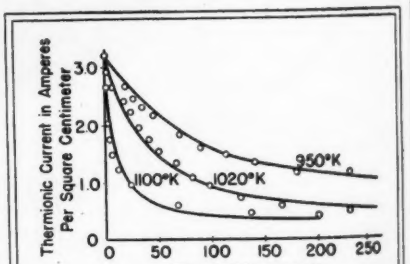

Fig. 1—Measured decay characteristics of tube No. 11 at different temperatures are shown by circles; lines show theoretically calculated curves. Data and calculations were normalized to start at the same initial current

positive and negative parts of the cycle were variable in steps. To avoid spurious interference, the multivibrator oscillator generating these pulses was synchronized to the power line, and all power supplies were electronically regulated.

A special peak-reading comparison vacuum-tube voltmeter with a calibrating pulse source was used to measure the decay characteristic of the emission pulse current.

Observed emission behavior is

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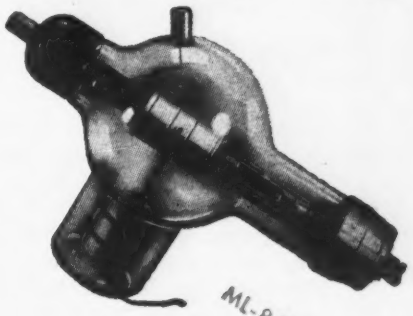

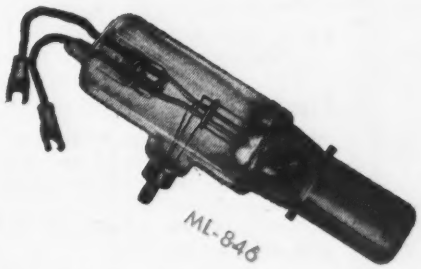

WHEN first announced, in 1938, the Machlett Dynamax represented the solution of the most difficult problems ever encountered in electron tube manufacture—paralleled only by the Machlett VM-1, the first precision, sealed-off, 2,000,000-volt dc tube.

The Dynamax was designed to meet the demand for a dependable, high-capacity X-ray tube that would give much sharper definition under the most adverse conditions. The desired results could be obtained only by using a very small focal spot, and an electron beam of high energy, 100 KV, .5 amp. Concentrating so much energy on a small spot meant destruction of target and tube unless the heat could be dissipated. Rotating the target was found to be the most effective means of protection, but this produced a much greater problem, that of lubricating the motor bearings inside the envelope without impairing the vacuum through distillation of the lubricant. A novel method of coating the bearings with a film of pure metallic silver was developed by Machlett engineers, with the result that the weakest spot became the strongest.

Today, Machlett rotating-anode tubes give over 200,000 exposures, over ten times the normal life expectancy of X-ray tubes of only a few years ago, and *more than twice that of present-day conventional stationary-anode tubes!* This is the preferred type for use in mass health surveys and busy institutions where the load is too great and too constant for any other tube. You will be interested in the full story of the Dynamax—write for your copy today; it will be sent with our compliments.

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explained on the theory that, under the influence of the electric field that draws off electrons from the emission surface, the barium (or strontium, or calcium) ions formed by the loss of emission electrons are induced to drift from the outside crystal surface back into the emission layer. (Measurements indicated that from 5 to 50 percent of the total conduction current within the crystals is ionic). Thus the instant emission begins, the surface is covered with low work-function barium atoms, but after

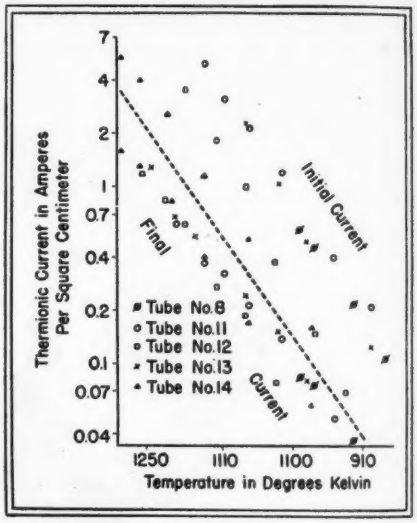

Fig. 2—Initial and final current values for various tubes at different temperatures

a short period of emission the surface is composed of ions and atoms thus having an apparently higher work-function. Equilibrium is reached when the rate of inward ionic diffusion and creation of ions at the surface are equal. Equations for the decay from initial to final value of the emission current derived from this theory check with observations as shown in Fig. 1.

Effect of Pulses

To determine the dependence of emission decay on the duration and repetition rate of pulses, emission duration was varied from 100 to 300 microseconds at a repetition rate of 30 pulses per second. No change in decay rate was observed. Repetition rate was varied from 20 to 120 pulses per second at an emission duration of 300 microseconds, and no change in decay

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rate was observed. However at a frequency of 600 cycles per second, the ratio of initial to final current was reduced about 20 percent indicating that the surface did not have sufficient time to recover from its partially ionized state. This test was conducted on tube No. 8 at a cathode temperature of 920 degrees Kelvin.

Table—Composition and thickness of typical coatings used in the tests

Tube No.	Composition (by weight in %) BaO	SrO	CaO	Thickness (mg/cm²)
8	50	50		1.2
11	50	50		5.2
12	50	50		9.0
13	60	30	10	32.0
14	50	50		0.8

Effects of temperature are given in Fig. 2. Decay was found to be independent of the oxide coating thickness within the range of thickness indicated in the table.

• • •

Navy Radio-Technician Training

By RUTH LAWYER

Editor, Technical Education News
McGraw-Hill Book Co., Inc.

TO TRAIN OPERATORS and service men for the multiplicity of electronic equipment carried by Naval ships and planes, the Navy is conducting an enlarged, accelerated technical training program. Bellevue, the permanent Navy Radio Materiel School, shares with the Naval Research Laboratory a site on the Potomac a few miles from the center of Washington. Three other temporary schools—Treasure Island, San Francisco; Navy Pier, Chicago; and Corpus Christi, Texas (the latter devoted to training in airborne equipment)—carry on similar programs.

At Bellevue, there is a staff of 168, a student enrollment of 1900, with 135 new men entering every two weeks.

All the faculty have been through the school themselves. Commanding officer Comdr. Raymond Cole, USN; executive officer Lt. Comdr. Nelson M. Cooke, USN; and technical training officer (corresponding to dean of students) Lt. F. C. Atnip, are familiar from years of experience with the ways of the Navy. Intercom systems connect

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tests, mechanical and electrical tests, and radio tests. Once past these hurdles, students go through one month pre-radio school, which is primarily for screening, orientation and basic training. They then go to a three-month elementary electronics and radio materiel primary school of which there are six scattered throughout the country. At these schools, the men are given

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Quality is built on the firm foundation of unselfish service. Before men can desire to build quality into their work, they must first desire to serve their fellow men well. Mediocre and inferior men build quality through pressure of competition or fear of censure. Leaders of men give and maintain quality because in so doing they render the kind of service they believe is worthwhile, and because they desire the satisfaction, recognition and rewards their leadership merits. Not the least of these satisfactions is the improvement of standards in those who must follow the leader.

True service demands the best quality.

President

LITTELFUSE *Incorporated*

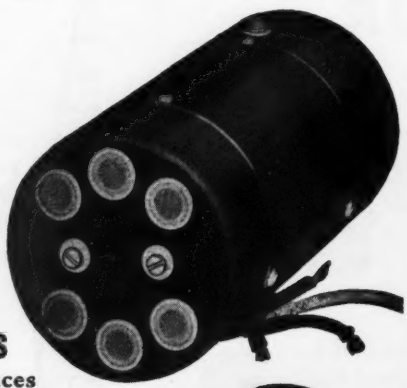
SKILL

To Meet Your Specifications

PERFORMANCE is the real measure of success in winning the war, just as it will be in the post-war world. New and better ideas—production economies—speed—all depend upon inherent **skill and high precision** . . . For many years our flexible organization has taken pride in doing a good job for purchasers of small motors. And we can help in creating and designing, when such service is needed. Please make a note of Alliance and get in touch with us.

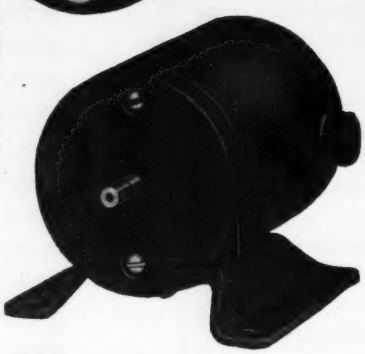
ALLIANCE DYNAMOTORS

Built with greatest precision and "know how" for ***low ripple—high efficiency—low drain*** and ***a minimum of commutation transients.*** High production here retains to the highest degree all the "criticals" which are so important in airborne power sources.



ALLIANCE D. C. MOTORS

Incorporate precision tolerances throughout. Light weight—high efficiency—compactness. An achievement in small size and in power-to-weight ratio. Careful attention has been given to distribution of losses as well as their reduction to a minimum.



Remember Alliance!
—YOUR ALLY IN WAR AS IN PEACE

ALLIANCE MANUFACTURING CO.
ALLIANCE . OHIO

Ranging) equipment. This includes studies of the physics of sound; echo-ranging, listening and sounding equipment; and plotters, recorders, and indicators.

Sonar, used in submarine warfare, depends upon the echo of supersonic frequencies sent through the water. Students learn how to install and operate this equipment. Units are installed for demonstration, often necessitating variations by the maintenance staff to simulate shipboard operation.

Recently installed sonar equipment is built into a two-story arrangement with receiver-indicators on the upper deck, the hoist-train equipment and drivers on the lower deck, and the supersonic sound projectors submerged in a tank below.

DIVISION 5: The applications of these same echo principles are studied in connection with radar (RAdio Direction And Ranging.) The

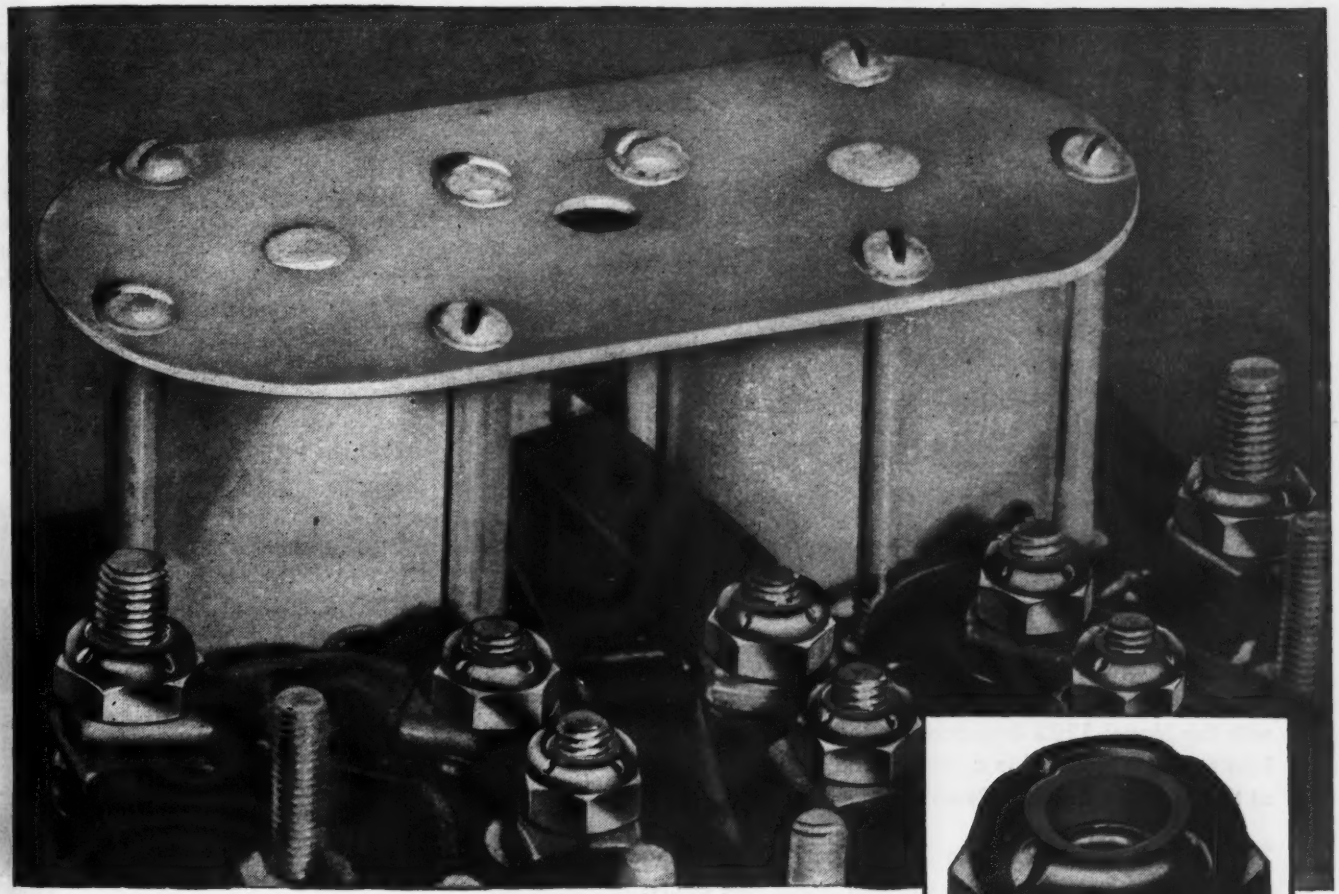
Before leaving school, radio technicians become familiar with Naval communication and navigation equipment through laboratory work

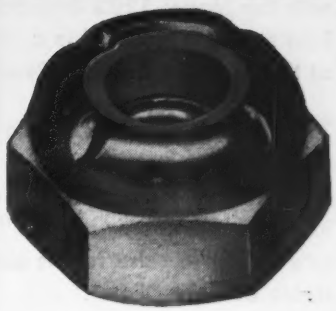
equipment on which the students work includes microwave search gear, air search and surface search radar, fire control, identification, and counter radar.

The fundamental operation of all these units is that distance can be accurately measured by transmitting pulses of radio energy and receiving these pulses as reflections from distant objects. Intricate electrical timing and amplifying circuits and cathode-ray visual indicators are used. The signal indication on the calibrated oscilloscope gives, at a glance, the range to an echoing object.

Direction can be determined by sending out beams of radiant en-

Best FOR SURE CONTACTS





FOR ELECTRICAL CONNECTIONS USE ELASTIC SELF-LOCKING STOP NUTS

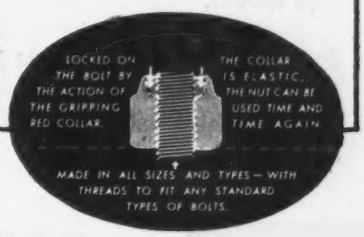
With the assured high conductivity of a soldered connection, combined with the great advantage of easy removability for servicing and overhaul, Elastic Self-Locking Stop Nuts are being given new responsibilities in the field of electronics every day.

They've been found the best kind of insurance against loose contacts where there are terminal connections in circuits, as in the starting motor relay switch illustrated.

Manufacturers and servicemen turn to the nut with the famous red collar to help eliminate failures and poor operation of electronic equipment arising from loose contacts — because the Elastic Stop Nut's red collar has proved it holds fast. The elastic compression collar forms itself to the bolt threads, and the nut refuses to loosen, creep, or back off the bolt under the most difficult operating conditions.

For reliability, safety and economy, use Elastic Self-Locking Stop Nuts wherever vibration, shock, impact or similar loosening influences are encountered.

LOOK FOR THE RED COLLAR
THE SYMBOL OF SECURITY

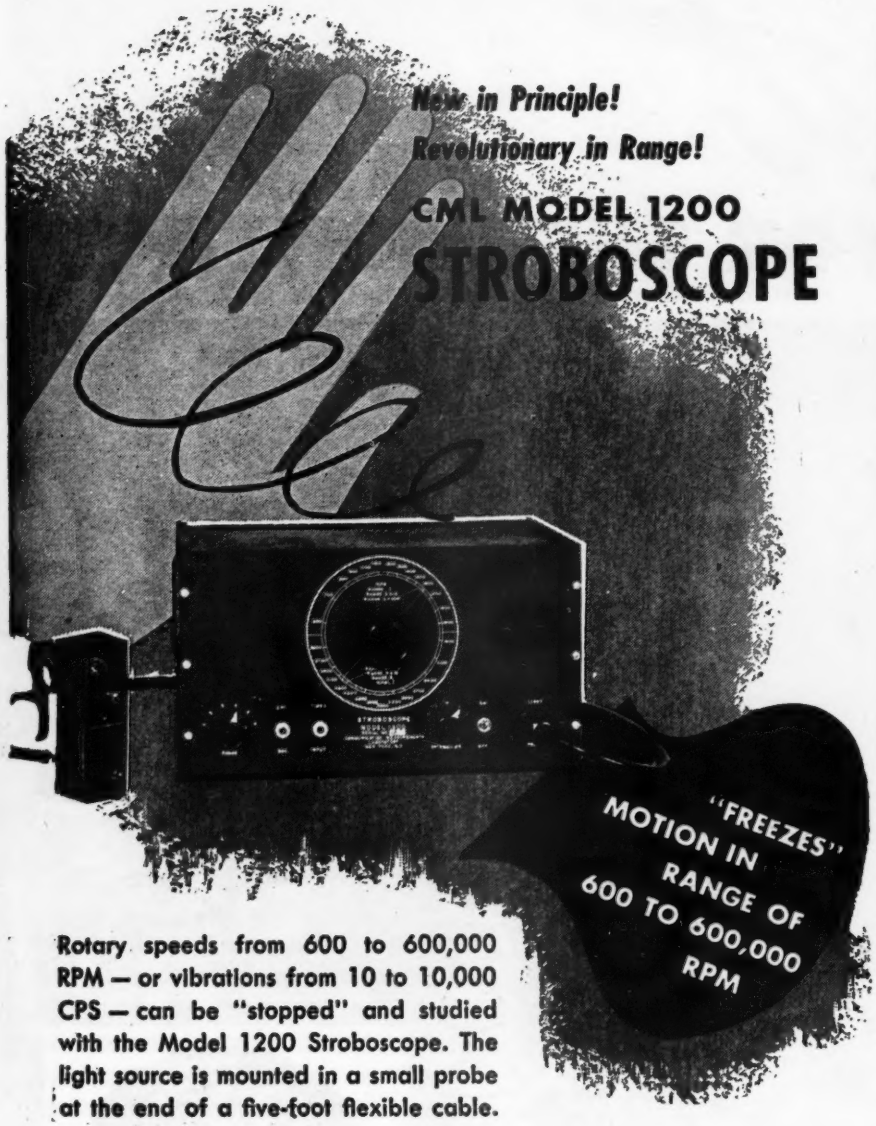

LOCKED ON THE BOLT BY THE ACTION OF THE GRIPPING RED COLLAR.
THE COLLAR IS ELASTIC, THE NUT CAN BE USED TIME AND TIME AGAIN.
MADE IN ALL SIZES AND TYPES — WITH THREADS TO FIT ANY STANDARD TYPES OF BOLTS.

ESNA
TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Plants at Union, N. J. and Lincoln, Neb.

Sales Office: Union, N. J.



Rotary speeds from 600 to 600,000 RPM — or vibrations from 10 to 10,000 CPS — can be "stopped" and studied with the Model 1200 Stroboscope. The light source is mounted in a small probe at the end of a five-foot flexible cable.

This makes it easy to examine small objects at close range. Provision is made to operate the unit from external tuning fork or crystal standards, where extreme accuracy is required. The motion of objects moving at irregular speeds may also be "stopped" with the Model 1200. An accurate repetitive pulse rate is obtained, as the pulses are derived from a stable audio oscillator.

Not only does this eliminate the necessity for constant readjustment of the repetitive rate, but it also insures clearly defined images at high speeds.

For greater flexibility, a light intensity control switch is also provided. This enables the user to control both the intensity of the light and the duration of the pulse length.

WRITE FOR DESCRIPTIVE BULLETIN

COMMUNICATION MEASUREMENTS LABORATORY

Ratiobridge • Electronic Generators • Power Supply Units

120 GREENWICH ST., NEW YORK 6, N. Y.

ergy from revolving directional antenna arrays. Special radar devices are used that are unaffected by clouds and fog.

DIVISION 6 and 7: The course is concluded with study of precision radar equipment and special electronic devices.

Fleet Performance

As a check on the fleet performance of graduates, report from each man's commanding officer listing his technical ability, petty-officer potentialities, and general worth to the service is sent to the school. These comments enable the school to check teaching needs and methods so as to keep abreast of fleet requirements and practice, and to anticipate and eliminate the common faults of radio technicians.

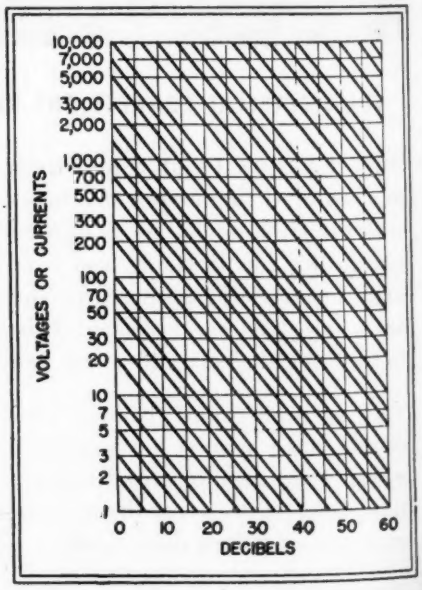
• • •

Decibel Calculator

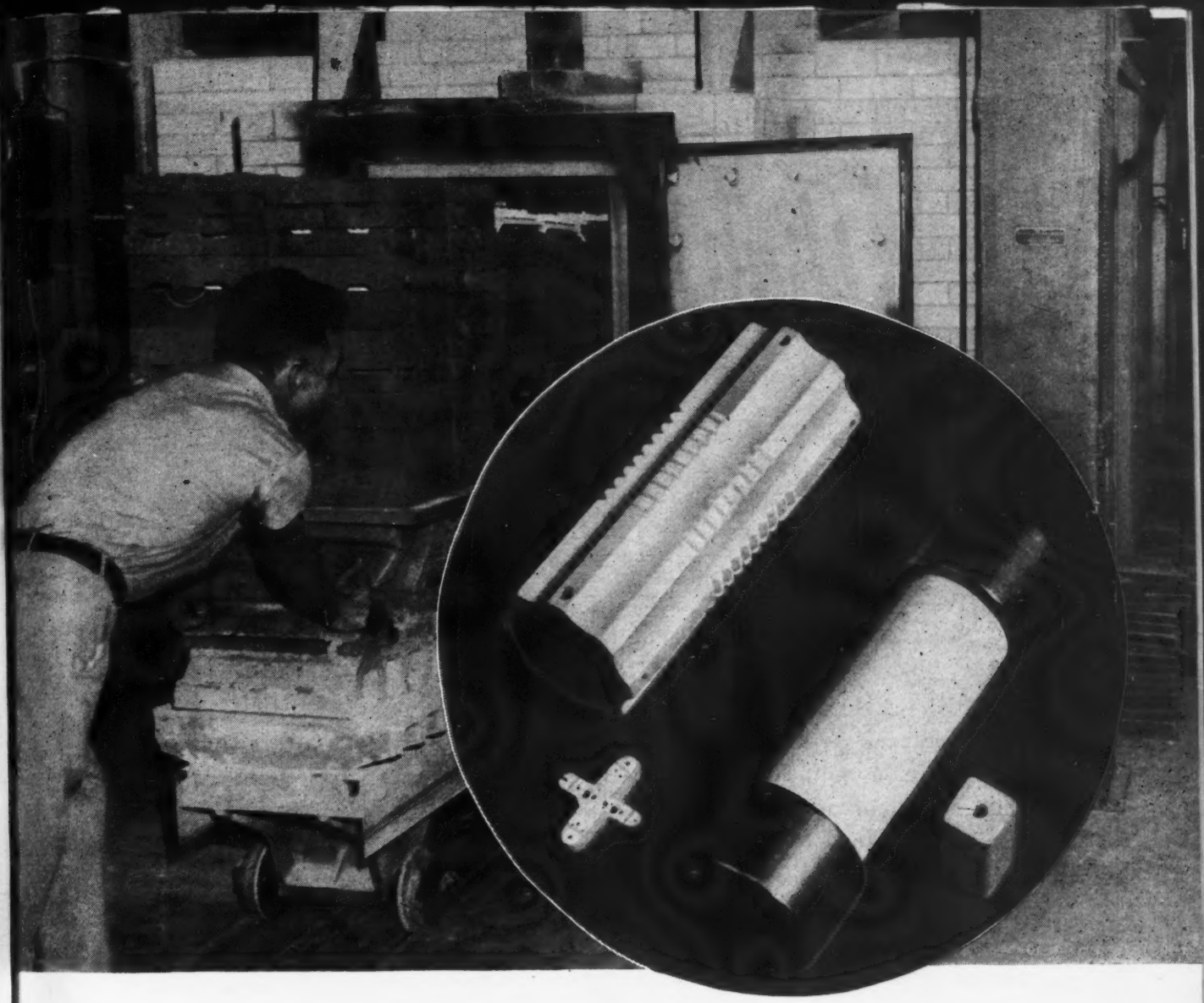
By GERSHON J. WHEELER
Brookline, Mass.

THE ACCOMPANYING NOMOGRAPH is a vestpocket chart for calculating decibels when either the voltages or currents at the input and the output of a circuit are known. It is not necessary to compute the voltage or current ratio, the chart does this at the same time it converts them to decibels.

To find the decibel equivalent



Nomograph for converting two voltages or currents into their corresponding db ratio. Note that the chart repeats itself every 20 units along the db axis and every power of ten along the voltage or current axis



BORN AT 2500°F.

AlSiMag is master of power and heat because it takes its final, strong, hard, *rigid* form in furnaces at the white heat of 2500°F.

This inorganic material cannot char. It withstands red heat temperatures of 1800°F. AlSiMag is highly resistant to thermal and electrical shock.

AlSiMag insulators do not distort with loading nor cold-flow with time. They are non-corrodible.

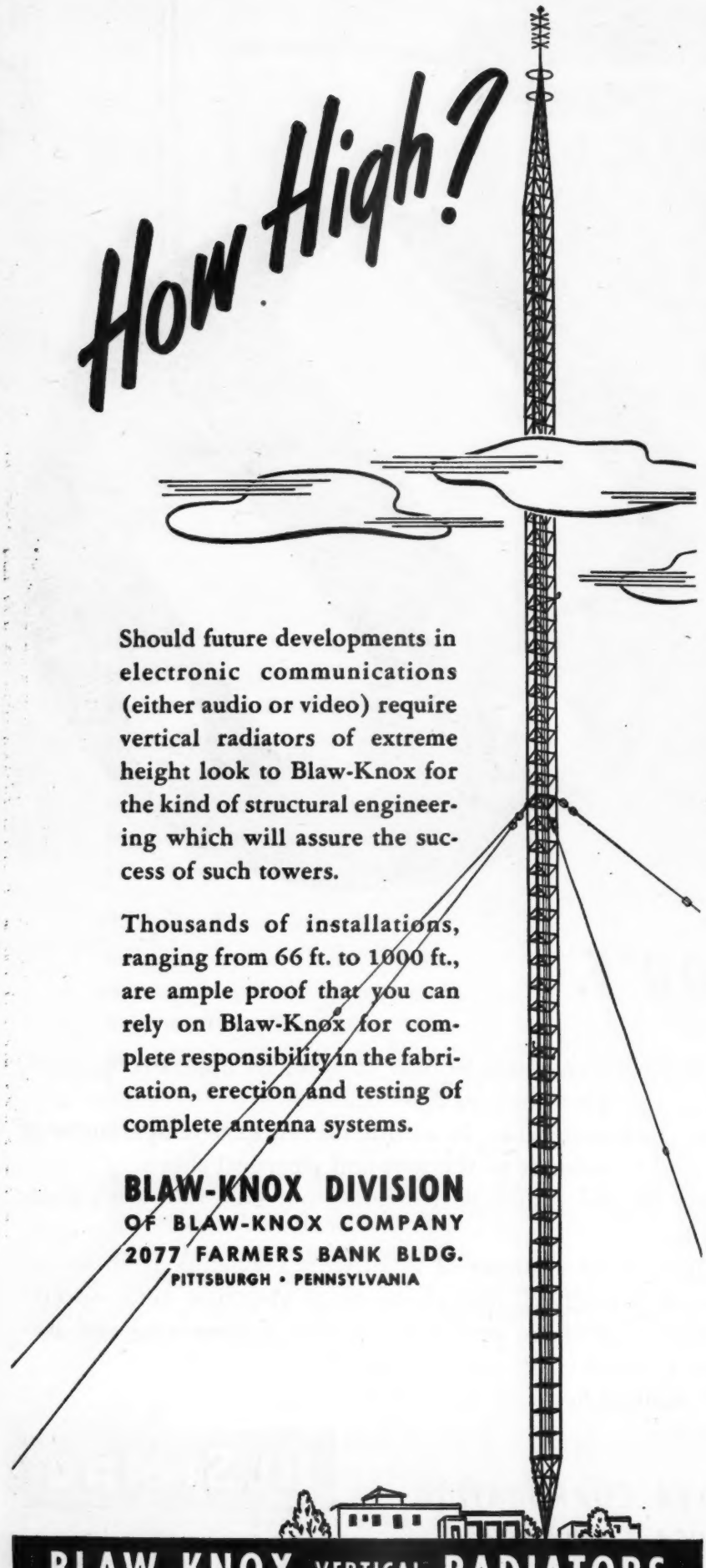
Uniformity and dimensional accuracy of AlSiMag Insulators facilitate assembly. Whatever you are planning in the electronic or electrical field—specify AlSiMag for long-lived, dependable performance. Our Engineering and Research men are anxious to work with you. Literature applicable to the various fields of AlSiMag uses, available on request.

ARMY ★★ E ★★ NAVY

ALCO has been awarded for the fifth time the Army-Navy "E" Award for continued excellence in quantity and quality of essential war production.

AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE

AlSiMag
TRADE MARK REGISTERED U. S. PATENT OFFICE
STEATITE CERAMICS



Should future developments in electronic communications (either audio or video) require vertical radiators of extreme height look to Blaw-Knox for the kind of structural engineering which will assure the success of such towers.

Thousands of installations, ranging from 66 ft. to 1000 ft., are ample proof that you can rely on Blaw-Knox for complete responsibility in the fabrication, erection and testing of complete antenna systems.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2077 FARMERS BANK BLDG.
PITTSBURGH • PENNSYLVANIA

BLAW-KNOX VERTICAL RADIATORS

when two voltages are known; enter the graph at the left at the higher voltage, follow the diagonal downward to the right until the ordinate of the lower voltage is reached, the abscissa of this point gives the number of decibels corresponding to the ratio of the two voltages.

If the input voltage is larger than the output voltage, the db valve is, of course, loss; if the input is smaller than the output, the valve is gain. Currents are treated similarly to voltages. If powers are given instead of voltages or currents, divide the final db by two. If ratios are given, simply assume that the ratio is the first voltage, current or power, and that the second one is unity.

• • •

Generation of Millimeter Wavelengths

A METHOD OF PRODUCTION, detection and measurement of extremely short electromagnetic waves is described by Jean P. Cooley and John H. Rohrbaugh in the *Physical Review* for May 1 and 15, 1945.

Waves were produced having lengths between 2.2 and 0.2 mm by using small aluminum particles, suspended in a continuously flowing stream of oil, as dipole radiators. A shock excitation circuit was used generating 1000 surges per second of steep wave front and short duration. These pulses were applied to a 1-cm gap containing the oil stream to supply the necessary electric field.

Detection was accomplished by a bismuth-antimony thermopile which had all junctions covered with a 2-mm coating of 50 percent lamp black and 50 percent tellurium-plated cork dust. The output of the thermopile was fed to a galvanometer whose output was amplified electronically and optically.

Playback over a loudspeaker of recorded mating calls of mosquitoes attracts them to insect traps placed where the sound originates, recent experiment at Cornell University Medical College show.

Upside down and sideways—and this transformer puts in overtime!

This is just one more reason why Thermadors are known as America's quality transformers.

There is a machine called a Shaker. It goes up and down while it rotates. The motion varies from a gentle rhumba to an earthquake of cataclysmic proportions. In 10 minutes an ordinary transformer sails off into the steel mesh net.

At Aireon Manufacturing Corporation's Kansas City plant they bolted a Thermador transformer to the shake-bed of this machine. They turned the shaker on for an hour—then they left it going overnight, unbolted the Thermador transformer, connected it to the test line. The needle showed not an nth of variation.

Why this incredible performance? Just this. Transformers were formerly mounted to the cover of their cases. Thermador developed a strong stamped bracket from strip steel and projection-welded it to the case body—independent of terminal boards or covers. As a result, Thermador transformers can be mounted in any position—up and down and sideways—and take the worst beating you can give them.

THERMADOR ELECTRICAL MANUFACTURING COMPANY
5119 SOUTH RIVERSIDE DRIVE • LOS ANGELES 22, CALIF.

Thermador Transformers

DEFEAT COLD • HEAT • HUMIDITY

Seven Leagues Ahead

NEWS OF THE INDUSTRY

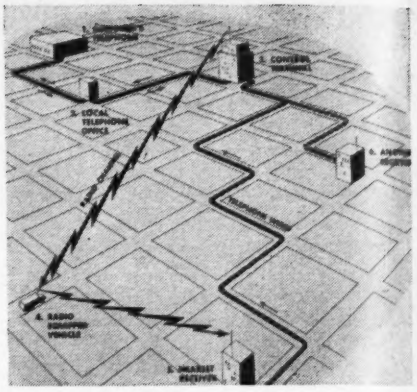
News of Washington; actions by the Federal Communications Commission; notes on meetings ahead; activities businesswise; and information about people you know

Japanese Quality

ACCORDING TO A REPORT by OWI, Japanese airborne electronic equipment made since 1940 is far superior to that of earlier design and actually is of excellent workmanship and material. Much aluminum is found in their designs providing unusually light gear. No precautions were found to have been taken in corrosion and fungus control, however.

Radio direction finders, standard equipment on medium and heavy bombers, were not reported to have been normally installed in fighter ships. Several Japanese Zero fighters have been found with radio equipment which had been made in the United States, in whole or in part, while components of German and British manufacture have been reported in units of Japanese manufacture.

All equipment reported on was hand made, with no evidence of quantity production.



Currently proposed urban mobile radiotelephone system with central 250-watt transmitter to contact vehicles and several receivers located at various points to receive calls from the low-powered vehicular units

Radiotelephones for Vehicles

APPLICATIONS have been filed with the Federal Communications Commission by the American Telephone and Telegraph Co. for authority to install radiotelephone stations to provide two-way voice communication with drivers of motor vehicles in Baltimore, Chicago, Cincinnati, Columbus, Denver, Houston, Milwaukee, New York, Philadelphia, Pittsburgh, St. Louis, Salt Lake City, and Washington, D. C.

The Bell System companies, planning to make the new service available first where public necessity is greatest, are making surveys to determine the need for and the feasibility of mobile radio telephone service in many other cities of the country.

In metropolitan centers, the plan is to use transmitters of about 250 watts power operating in the band between 152 and 162 megacycles. Receiving stations are to be located at various points to pick up signals from the 15-watt mobile units. The path of a typical call is shown in the illustration. Each mobile unit will use a single antenna for both sending and receiving.

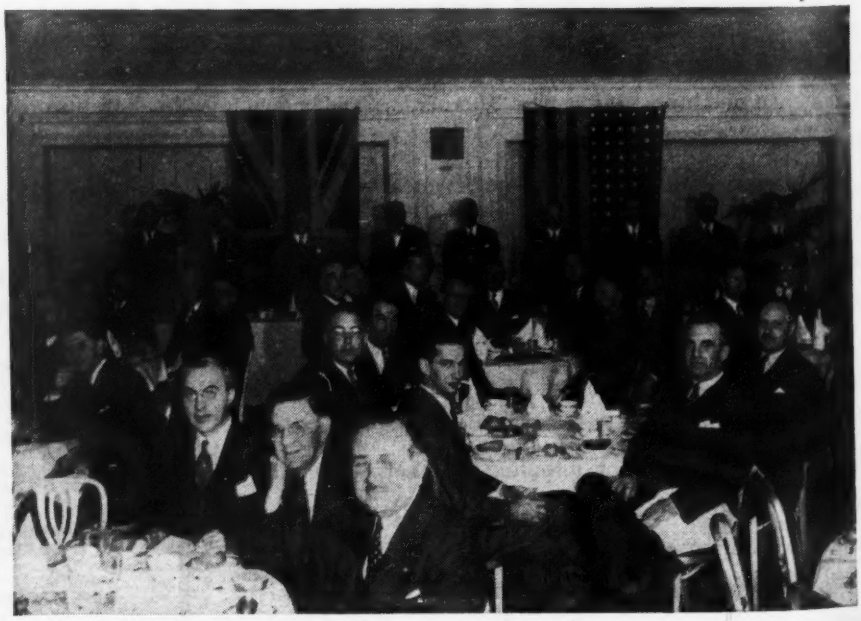
Calls to and from motor vehicles will be handled by special operators, the calls traveling part of the way by wire and part by radio. A caller at her desk dials or asks for the vehicular operator and gives her the call number of the vehicle. By dialing a code number, she causes an audible or visual signal in the vehicle to indicate to the driver that he is wanted.

The operator of a mobile unit can originate calls by picking up the telephone and pushing a button to signal the vehicular operator.

Another type of radiotelephone service which will be tried, would furnish two-way voice communication with motor vehicles operating on inter-city highways and boats on adjacent waterways. This service would require both transmitting and receiving stations along the highways to be served.

F-M Converters

ANNOUNCED AT A MEETING of the pioneer f-m radio manufacturers in New York recently is a new unit capable of providing f-m broadcasters with simultaneous transmission on frequencies in both the present 42-50 mc and the new 88-106 mc bands. New receivers are being designed with two f-m bands



Members of the U. S. and the Canadian RMA gather at luncheon in Montreal's Mount Royal Hotel

Unusual FACILITIES FOR UHF DESIGN AND POST-WAR PRODUCTION

Two things are vitally necessary for the design and production of UHF equipment . . . specialized knowledge and special equipment. We have both. Lavoie engineers are highly specialized along UHF lines. In our plant, the equipment and shop practice are centered on UHF requirements.

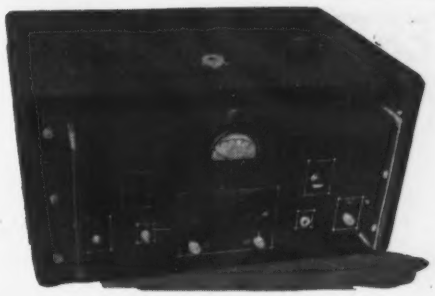
Lavoie service is available to you either in the form of technical recommendations only, or we can develop your ideas in actual physical form. This applies to absolutely new ideas or to the betterment of present ideas. We invite consultation.

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.



UHF HARMONIC FREQUENCY GENERATOR

PROVIDES output voltages which are multiples of 10 or 40 megacycles with CRYSTAL-CONTROLLED accuracy.

RECOMMENDED FOR: the calibration of receivers, wavemeters, or using internal beat detector for calibration of oscillators and signal generators.

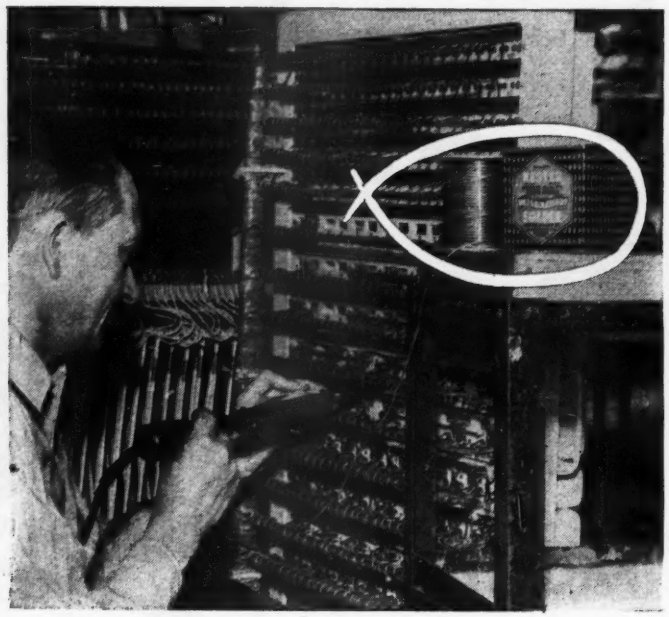
UHF PRECISION FREQUENCY METER

Completely portable
Accuracy 0.1%
Battery or AC-Operated

Models available from 100 to 1500 megacycles with 2 to 1 frequency coverage on each model Available only on high priority.

Specialists in The Development of UHF Equipment
and in The Manufacture of UHF Antennas

Match Fine Workmanship with Materials that LAST!



KESTER CORED SOLDERS

Assure Permanence

→ Workmanship is only as good as the materials used! Workmanlike soldering requires an accurately compounded, pure, balanced solder — one that holds tight against bending, vibration, shock, contraction, and expansion. Kester assures such permanence!

→ Kester Cored Solders are unexcelled for high quality and unvarying uniformity. Kester's 46 years research and practical experience gives you the right, permanent solder for every type of work.

→ Virtually mistake-proof, Kester Cored Solders are applied in one simple operation because the positive acting flux is contained right in the core — forms tight, clean solder-bonds, sure to stay put!

→ Specify Kester Rosin-Core Solder for electrical connections — Kester Acid-Core Solder for general work. Both are available in a wide range of core and strand sizes. Consult Kester Engineers, without obligation, on any soldering problem you may have.

KESTER SOLDER COMPANY
4204 Wrightwood Avenue Chicago 39, Ill.
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ont.

KESTER
Cored Solders
STANDARD FOR INDUSTRY

to provide reception in both the present and new channels. The transmitter converter is applicable to transmitters of any manufacture, supplies 1 or 3 kw output power at any frequency in the new band, requires no additional monitoring, and is supplied by Radio Engineering Laboratories, L. I. C., N. Y.

Good Engineering Practice

PROPOSED STANDARDS have been drawn up by FCC to serve as a basis for discussion of good engineering practice by f-m broadcast stations. They have not been approved by the commission.

Included in the contents of the notice announcing the proposals are: engineering standards of allocation; topographical data; interference standards; field intensity measurements in allocation; transmitter location; antenna systems; standard lamps and paints; transmitters and associated equipment; indicating instruments; auxiliary transmitters; operating power—determination and maintenance; frequency and modulation monitors at auxiliary transmitters; requirements for type approval of transmitters, frequency monitors, and modulation monitors; approved transmitters, frequency monitors, and modulation monitors; and application forms.

Hearing Aid Standards

AFTER EIGHTEEN MONTHS of active compilation and testing, the American Hearing Aid Association, 77 W. Washington St., Chicago 2, Ill., has released a set of specifications covering the scientifically accurate measurement of performance characteristics in hearing aids.

Drawn up by a group of hearing-aid engineers forming a special committee for this purpose, the original recommendations were tested by being put tentatively into actual practice in the laboratories of manufacturers. Experiences were reported back to the committee and modifications made.

It is the expectation of AHAA that the material will eventually be issued by American Standards Association, perhaps in expanded form. The present publication, copies of which can be obtained

SOUND EQUIPMENT – *precisionized* – mechanically and electronically – *for finer performance*

IMMEDIATE DELIVERY!

Unit 540

a limited number of Fairchild AMPLIFIER-EQUALIZERS!

UNIT 540 is the latest model Fairchild Amplifier-Equalizer. Its design permits the unusual operational advantage of *unlimited frequency selection* over two critical ranges: 20 to 100 cycles; 4,000 to 10,000 cycles with an available boost of 0 to 20 db.

Unlimited frequency selection compensates for brilliance-loss at the slower 33.3 speed and for response-deficiencies of cutterhead, disc material, pickup or speaker by electronically boosting the higher frequencies from 4,000 on up to 10,000 cycles — with a negligible effect on volume and without loss in the bass.

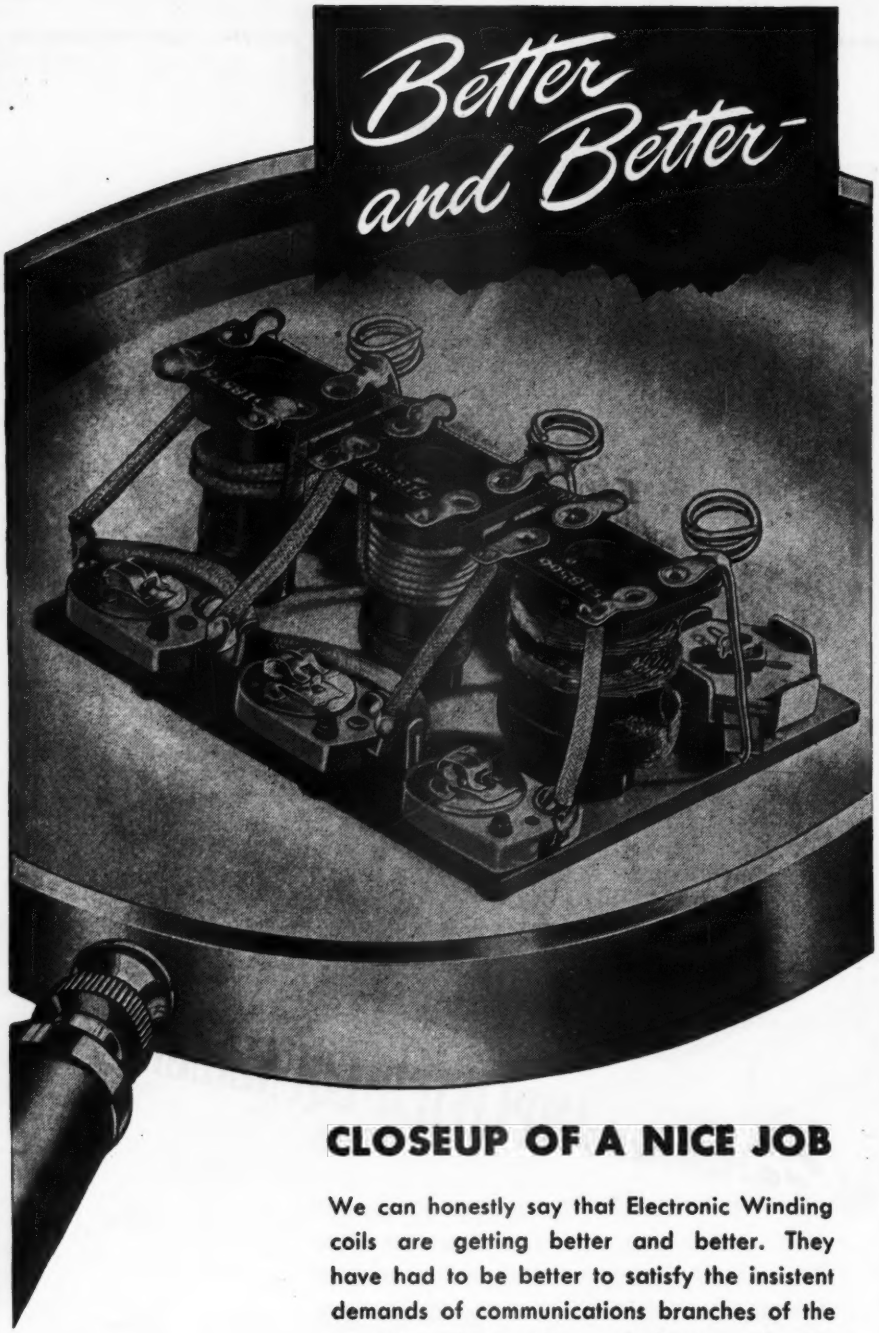
Unit 540 can be used with two recorders to record or play back continuously by switching from table to table; to make two identical records at the same time; or to 'dub' from one table to the other as in copying a recording played on one table and recorded on the other.

Unit 540 is compactly designed to fit into a light-gauge metal trunk measuring 17" x 18" x 11". It can also be rack mounted. And provision has been made in the inputs and outputs to permit operation under many varying conditions — to meet the exacting professional requirements of the radio and communications fields.

Descriptive and priority data are available. Address *New York Office:* 475 — 10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Blvd., Jamaica 1, New York.

Fairchild CAMERA AND INSTRUMENT CORPORATION

SOUND EQUIPMENT



CLOSEUP OF A NICE JOB

We can honestly say that Electronic Winding coils are getting better and better. They have had to be better to satisfy the insistent demands of communications branches of the armed services and to contribute to the dependability of rugged radio equipment that is helping to save lives all around the world. This closeup of a nice job of coil winding shows a complete RF assembly — just one of the many precise jobs we can do. If specifications call for a coil of *extra quality* call on Electronic Winding.

Electronic Winding Co.

5031 BROADWAY
CHICAGO 40, ILL.

★ ★ MANUFACTURERS OF EXTRA QUALITY COILS FOR PRECISION COMMUNICATIONS EQUIPMENT

from the Chicago address, include; general method of measuring acoustical gain; test room; sound source; measurement of sound field; artificial ear and associated equipment; mounting of hearing aid for test; determination of frequency response; effect of battery voltage variation; measuring non-linear distortion; measuring acoustic-input-output characteristics; measuring battery drain; and variation of gain with temperature and humidity changes.

Research and Equipment Expenditures

PRAISING THE CONTRIBUTION to the war of OSRD, the House Appropriations Committee recently granted $70 million for operations the next fiscal year, only $7,500,000 below budget estimates.

One of the features of the hearing was testimony by Dr. Vannevar Bush to the effect that the radar development job would have been large in peacetime if spread over 15 years. Radar research expenditures by OSRD were cut from $42,118,342 to $25 million.

In other appropriations hearings, General Brehon Somervell revealed the following figures, in thousands of dollars for Signal Corps procurement, excluding items transferred to the Air Forces in last April's reorganization.

	1944 Actual procurement	1945 Scheduled Procurement As of May 31, 1945	1946 Scheduled Procurement, May 31, 1945
Ground Radar.....	205,203	178,214	61,662
Special Ground.....	42,529	25,056	6,217
Ground and Vehicular.....	381,013	248,140	102,218
Telephone and Telegraph.....	203,607	118,882	67,211
Wire and Cable.....	196,868	223,184	280,490
Miscellaneous.....	482,160	481,974	466,355
Totals.....	$1,511,380	$1,275,450	$904,153

FM for Trucks

ACCORDING TO THE PLANS of Highway Radio, Inc., all motor trucks moving over America's highways may eventually be linked with their terminals and with each other by f-m radio. The organization has already asked FCC for permission to equip 100 Chicago trucks on an experimental basis.

Advantages are that distribution

ANTENNAS ARE DIFFERENT

PHOTO BY HENRY B. KANE

The antenna of a grasshopper is a streamlined job... sensitive... functional... perfectly adapted to its use. Today's antennas—for war or peace—must likewise fit the function, be it Radar or communications.

We at the Workshop design and manufacture antennas to meet the most exacting electrical and mechanical specifications. Our facilities, which include electronic test equipment for measuring antenna gain, pattern, and impedance, provide us with fundamental data beyond the reach of the average manufacturer.

If you have an antenna problem in the very-high, ultra-high, or microwave frequency bands, get in touch with us — we are anxious to serve you.

The WORKSHOP ASSOCIATES

Antenna Manufacturers

FOR THE ELECTRONIC INDUSTRY

66 NEEDHAM STREET • NEWTON HIGHLANDS 61, MASS.

At the advent of war we created an entirely new department for the manufacture of fabricated parts and assemblies. With a half century of experience to draw on, our training in precision work, the care and attention to detail necessary to production of fine decorative parts, the metallurgical experience and the understanding of fine finishing, proved of immense value in meeting the exacting requirements of industrial parts.

This department today is producing such critical items as collector rings, radio and radar parts, aircraft instrument parts, copper finned radiators for power tubes and other specialized fabrications.

Working on the sheet, wire, and tubing which we fabricate in our mill operations, we are able to carry out punch press and deep drawing work, milling, turning, grinding, and drill press operations. In addition, we have facilities for silver soldering and silver furnace brazing and fine polishing.

To assist you in the application of our products to your products we are maintaining a staff of thoroughly experienced metallurgists, chemists, designers and consultants . . . an up-to-date research and testing laboratory . . . and a splendidly equipped tool room. These are all at your service to cooperate with your own staff to the full extent of our facilities.

Your inquiries are cordially invited. Ask, too, for a copy of our new descriptive folder.

START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS
FABRICATED PARTS AND ASSEMBLIES

D. E. MAKEPEACE CO.
MAIN OFFICE AND PLANT ATTLEBORO, MASSACHUSETTS
New York Office, 30 Church St. Chicago Office, 55 East Washington St.

can be expedited by dispatching trucks while still on the move; traffic during storms may be made safer by routing trucks over clear roads; and help can be sent quickly in cases of accident or mechanical failure.

One 250-w transmitter is projected to serve as a control station for trucks entering and leaving Chicago. A 30-w portable-mobile station is also included. Frequencies of 42,000 and 39,140 kc are being requested and the expectation is that reliable communication will be established within a range of 40 to 50 miles from the land station with spot communication possible to distances of 80 miles.

RMA Activities

WINDING UP the 21st year of its operations, Radio Manufacturers Association had a proxy membership meeting in Chicago during June. Annual reports are published and have been distributed.

R. C. Cosgrove was reelected president of RMA for another year while two new vice presidents, M. F. Balcom and George Lewis, were elected to succeed David T. Schultz and Walter Evans. One new director was elected, H. J. Hoffman—Machlett Laboratories—who replaces W. P. Hilliard of Bendix Radio.

Speaking of his predictions for the postwar future of the radio industry, Cosgrove envisioned an increase of 66 percent in employment and a competition so active that price controls would be rendered unnecessary. During the early months of civilian production, he expects actual losses because of limited production and high costs.

Membership was brought to a new high of 256 by the admission of: Argus, Inc., Ann Arbor, Mich.; Astatic Corp., Conneaut, Ohio; Call-A-Phone Mfg., Chicago; Gates Radio, Quincy, Ill.; Littelfuse Inc., Chicago, Ill.; Madison Electrical Products, Madison, N. J.; Standard Coil Products, Chicago; Teletone Radio, New York; Thomas & Skinner Steel Products, Ind.; and Thordarson Electric Mfg., Chicago.

Previously-announced additions to the roster included the following concerns: Armour Research Foundation, Chicago (associate member); ARF Products, River

ENCOMPASSING ALL FIELDS

wherein communications contribute to { SPEED / SAFETY / EFFICIENCY

On all points, Harvey-Wells communications equipment meets the need for high fidelity in transmission and reception.

Through intensive testing methods and exclusive engineering techniques, Harvey-Wells systems have made important contributions to communications in vital war operations. Their wide use by the armed forces is "proof positive" of their ability to deliver completely dependable service.

The unusually high standards fulfilled by Harvey-Wells receivers and transmitters are your guarantee of maximum efficiency in peacetime communications.

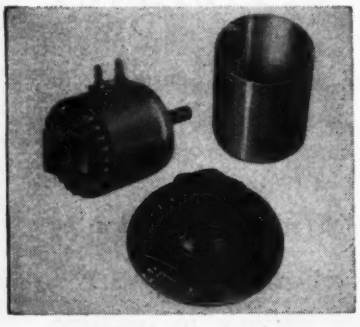
SETTING THE PACE FOR PROGRESS IN COMMUNICATIONS

Harvey-WELLS
ELECTRONICS
SOUTHBRIDGE, MASSACHUSETTS

FLAT Contacts
reduce noise, prolong service life

VARIATEN #1218
"T" Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$17.50

VARIATEN #1156
Ladder Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$12.50



VARIATEN #1658
Ladder Circuit—2½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$5.75

VARIATEN contacts and brush surfaces make contact over their entire area because the contacts are ground flat and the brushes stone-lapped, *not* buffed. Buffing produces rounded surfaces and therefore a "point" contact highly susceptible to noise. Variaten brushes move from one contact to the next without rocking motion. The resulting perpendicular spring pressure at all positions allows us to take advantage of the natural resiliency of metals to provide a completely flat contact over the entire brush surface at all times and so reduce noise and lengthen service life.

No carbon resistors are used in any Variaten Mixer...
All are of stable, wire-wound construction. Most are step type. Where quiet operation is the major consideration, we recommend ladder type mixers because the circuit requires only one contact brush operation on the input side of the circuit and any possible brush noise is therefore attenuated along with the signal.

By all means compare circuits, construction and features of these mixers. From the hundreds of Variaten attenuators you may select the attenuators best adapted to your specific needs. Write for the Variaten Catalog today.

VARIATEN

CINEMA ENGINEERING CO.
Established 1935 • Burbank • California

Forest, Ill.; Bell & Howell Co., Chicago; Tobe Deutschmann Corp., Canton, Mass.; Finch Telecommunications Inc., Passaic, N. J.; Hewlett Packard Co., Palo Alto, Calif.; Jefferson-Travis Radio Mfg. Corp., New York City; Permo Inc., Chicago; The Radio Craftsmen, Chicago; and The Radiotechnic Laboratory, Evanston, Ill.

A reorganization has been engineered by which the loudspeaker makers will be transferred from the amplifier and sound equipment group to the parts division. Section chairmen in the latter division for 1945-6 are: coils, Leslie F. Muter; fixed capacitors, Paul Hetenyi; fixed resistors, J. H. Stackpole; instruments, R. L. Triplett; insulations, John W. Apgar; metal stampings, S. L. Gabel; plastics, John J. Bachner; sockets, Frank Holmstrom; speaker parts, Henry C. Forster; special products, W. R. MacLeod; switches, Robert A. O'Reilly; transformers, Robert A. Hoagland; variable capacitors, Russell E. Cramer; variable resistors, H. E. Osmun; vibrators, Ray F. Sparrow; and wire, R. G. Zender.

Noise Standards

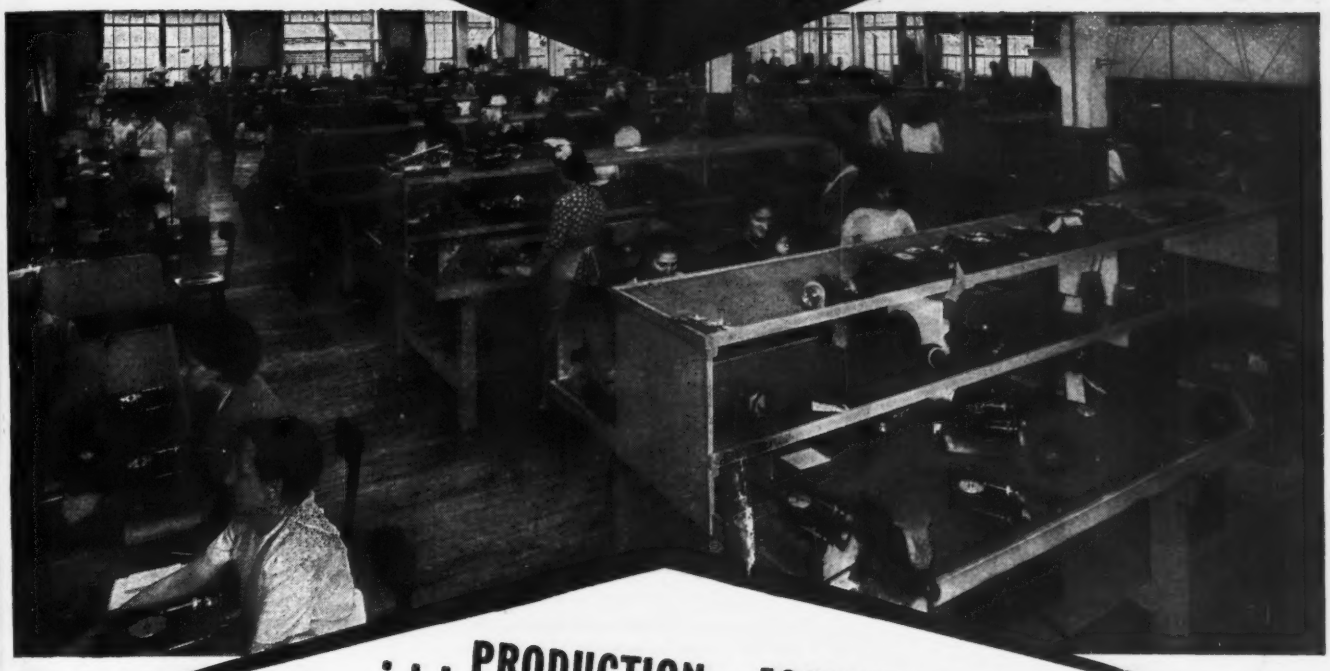
AMERICAN BUSINESS will participate in international work on standards covering the measuring of radio noise interference through ASA (American Standards Association). Active participation will probably wait until the completion of research now being carried on in this country. But the American Standards Association has agreed to an immediate interchange of technical information on the subject with other countries working through the United Nations Standards Committee.

RMA Production Code

MEETING IN MONTREAL, U. S. and Canadian RMA boards of directors and officers recently discussed joint problems. Among other activities an RMA code was approved. It is to be used in identifying production of radio apparatus, and was developed by the data bureau of the RMA engineering department.

Assignment has been made of three-digit figures to firms ranging from 101—Admiral Corp. to 343—Zenith Radio Corp. Markings will

AVAILABLE NOW....
AND FOR YOUR post-war planning



. . . PRODUCTION—ASSEMBLY FACILITIES of unique scope and efficiency

THE ATLAS ORGANIZATION, long recognized by leading industrial manufacturers for its ability to handle intricate problems in Engineering, Designing, Tooling and the creation of special Automatic Machinery, now offers an additional service to a few concerns who may require it.

During these war years we were called upon to design, equip and maintain in operation a HIGH SPEED, SUPER-PRECISION assembly department for the production of critical Radar equipment and exceptionally intricate instruments. The important work assigned to us has been, and is now being produced in its entirety, consistently meeting the time schedules and precision standards demanded.

If you have an idea or formulated product which you would like to sub-contract for unit production, we offer the services of a group comprising more than 400 skilled Engineers, Designers and Toolmakers, together with the finest machine, assembly and testing sections available for precise production.

Discussion of this interesting subject with our key men may solve your present problem and possibly get you off to a competitive advantage in postwar production. In other words, may we lift "a load off your shoulders onto ours"? Write or wire for a conference.

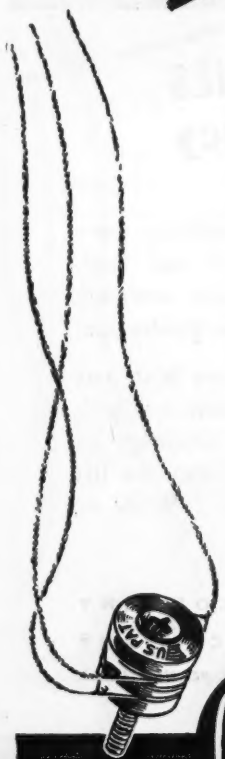
ATLAS METAL STAMPING COMPANY
ATLAS TOOL & DESIGNING COMPANY
CASTOR & KENSINGTON AVES., PHILADELPHIA 24, PENNSYLVANIA

. . . . ATLAS *a load off your shoulders . . onto ours*

Conant

introduces...

*Instrument Rectifier and Balanced Resistance network all combined in convenient plug assembly



Here is a brand-new development by Conant to meet the demand for applications involving the balanced bridge principle in AC operation.

Example: The conversion of standard Wheatstone bridge instruments to AC. In such applications, the AC accuracy and performance are equivalent to DC operation on the same instrument. Null indication is not affected by temperature, frequency, wave form or line voltage fluctuations.

This is but one of the multitude of uses for BALAC (trade mark—patent applied for).

Write or wire today for detailed information.

Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

20 Vesey St., New York 7, New York
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
2017 Grand Ave., Kansas City 8, Mo.
1212 Camp St., Dallas 2, Texas
378 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal
Export Div., 89 Broad St., N. Y. 4, N. Y
50 Yarmouth Rd., Toronto, Canada

start with these three digits followed by a figure 5 to designate the current year and another figure, for example, 21, to designate the week of production. Non-RMA members are expected to be included eventually.

Receiver Licensees

RADIO RECEIVER manufacturing licenses have been issued by RCA to: Telicon Corp., New York; Symphonic Radio & Electronic Corp., Boston, Mass.; Harris Mfg. Co., Los Angeles; Scientific Radio Products Co., Council Bluffs, Iowa; and Franklin Photographic Industries, Chicago.

Record-Changer Standards

WORK IS BEING DONE by the RMA engineering department for the standardization of record changers, pickups, and needles. Being considered are proposed dimensional standards of phonograph records for home use, proposed general electrical and mechanical specifications, terminology, and a standard warranty.

Speaker Standards

AT A RECENT MEETING of the committee on acoustic devices in the receiver-equipment group of the receiver section, RMA engineering department, discussion was held on speaker mounting dimensions and silhouettes. As a result, the work of correlating data was divided up so that each size unit will be handled by a single individual.

The following distribution was established: 3½ in., R. C. Bierman, Permoflux; 4 in., S. Zuerker, GE; 5 in., J. Q. Tiedje, General Instrument; 5¾ in., R. S. Anderson, Stromberg-Carlson; 6½ in., G. S. Holly, Radio Speakers; 7 in. M. E. Swift, Philco; 8 in. H. S. Knowles, Jensen Radio Mfg.; 4 × 6 in., J. P. Quam, Quam-Nichols; 5 × 7 in., J. L. Marquis, Operadio Mfg.; 6 × 9 in. C. E. Hoekstra, Magnavox.

Dam Radio

UNDER THE TERMS of bids recently opened by the Federal Bureau of Reclamation, shortwave radio equipment for emergency and operational communication is planned between remote, inaccessible stor-

★ ★ ★ ★ ★

Are You Launching a New Product with

LIMITED CAPITAL?

You've got the product, you've got the sales plans, the men and a sizeable piece of capital.

But first you feel you've got to get a plant, and tools and machinery, and set up a production line.

And it all takes capital! And when you get around to merchandising your product through the trade and to the consumer, that money is going to be spread woefully thin.

"Divide and Conquer"

Why not divide the job into "manufacture" and "distribution", and concentrate your available capital and your manpower on one part at a time. BUT reverse the usual procedure and get going on the *distribution first.*

Get your product into the hands of dealers and to the public, without waiting to set up a factory of your own. That can come later, and in good time.

The important thing is to get there with the goods first. Get entrenched in distribution channels ahead of the other fellow in the mad scramble for that pent-up demand for consumer goods.

Let Lewyt be your factory

You can eliminate factory investment, inventory in materials and labor . . . and cut a sizeable chunk of time from your delivery schedule if you "Let Lewyt Do It".

You may find that we can actually save you money on the production. We are so accustomed to finding short cuts in tooling-up, economies in assembly methods, that getting a new job going in jig time and without lost motion comes natural.

Let us take over the production end . . and you concentrate your capital and your efforts on the distribution. It's a combination that can get you off to a head start in the consumer market on that new product of yours.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 62 Broadway, Brooklyn 11, N.Y.

ARMY E NAVY

Lewyt

FOR MORE THAN 50 YEARS A CONTRACT MANUFACTURER... EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS AND SUB-ASSEMBLIES, TO THE MOST EXACTING REQUIREMENTS

CONTINUE BUYING WAR BONDS

WE MANUFACTURE

Radio coils
- **Solenoids**
- **Bank-wound**
- **Universal**
- **Universal progressive**
- **Paper section**
- **Layer-wound**
- **Toroids**

From the middle of the voice frequency to ultra-high frequency. Electronic and radio equipment of all kinds.

WE HAVE EQUIPMENT

FOR ANY TYPE OF TREATMENT:
- **Hermetic**
- **Wax**
- **Varnish-impregnating**
- **Baking, vacuum-impregnating**
- **Oil filling**

We have a completely equipped laboratory with Q meters, twin-"T" bridges and special bridges . . . for frequency analyzing and prime standard of frequency.

ALSO

We are equipped for turning out special sub-assembly work . . . work on complete units where allied to our various facilities as well as small punch press work . . . lugging and terminal assembly . . . soldering, testing . . . original design and product design.

We invite you to consult with us without obligation.

COMMUNICATION PARTS
NOT INC.
1101 NORTH PAULINA ST. • CHICAGO 22, ILLINOIS

age reservoirs in the headwate regions of the Minidoka and Snak River irrigation development i Idaho. Five radiotelephone set will be purchased to replace a non commercial telephone system whic has been undependable. Frequenc has been assigned on 2822 kc wit operations restricted, except in an emergency, to the period between local sunrise and local sunset.

Communications Statistics

RECENTLY PUBLISHED by FCC is a compilation for the year ending December 1943 of statistics in the communications industry of the United States. Comprising two sections, the book starts with financial and operating data relative to telephone, wire-telegraph, ocean-cable and radiotelegraph carriers and controlling companies and concludes with financial and operating data relative to standard broadcast stations and networks. The latter section includes general remarks and statistical data on broadcast revenues, tangible properties, employment and compensation, and radio homes in the United States by districts, regions, and states.

Copies are available from the Superintendent of Documents, Washington 25, D. C., at 35 cents each.

Capacitor Standards

FIXED CERAMIC-dielectric capacitors are covered in standards proposal No. 157 distributed by the RMA data bureau and covering sizes and characteristics, designation and markings, test methods, tests and component selections. Copies have been circulated for comment and criticism.

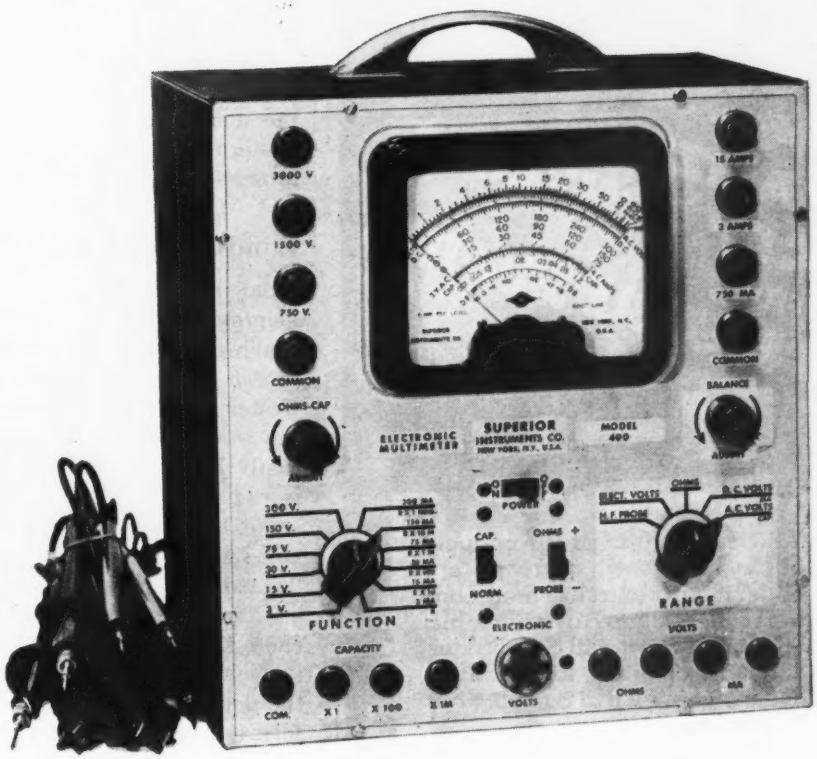
NAB Activities

RECENT ANNOUNCEMENT by NAB (National Association of Broadcasters) revealed the appointment to its presidency of Associate Justice Justin Miller of the United States Court of Appeals to succeed J. Harold Ryan. Ryan goes back to the vice-presidency and general managership of Fort Industry Co., Toledo, Ohio.

Other office holdings include: Frank M. Russell, NBC, and Frank Stanton, CBS, as network directors, and G. Richard Shafto, WIS, as di-

The New Model 400

ELECTRONIC MULTI-METER



A COMBINATION
VACUUM-TUBE
VOLTMETER
AND
VOLT-OHM
MILLIAMMETER
PLUS
CAPACITY
INDUCTANCE
REACTANCE
AND
DECIBEL
Measurements

Specifications:

D.C. ELECTRONIC VOLTS:
(At 11 Megohms input resistance)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

D.C. VOLTS:
(At 1,000 Ohms Per Volt)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

A.C. VOLTS:
(At 1,000 Ohms Per Volt)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

D.C. CURRENT:
0 to 3/15/30/75/150/300/750 Ma.—0 to 3/15 Amperes

RESISTANCE:
0 to 1,000/10,000/100,000 Ohms—
0 to 1/10/1,000 Megohms

CAPACITY: (In Mfd.)
.0005—.2 .05—20 .5—200

REACTANCE:
10 to 5M (Ohms) 100—50M (Ohms)
.01—5 (Megohms)

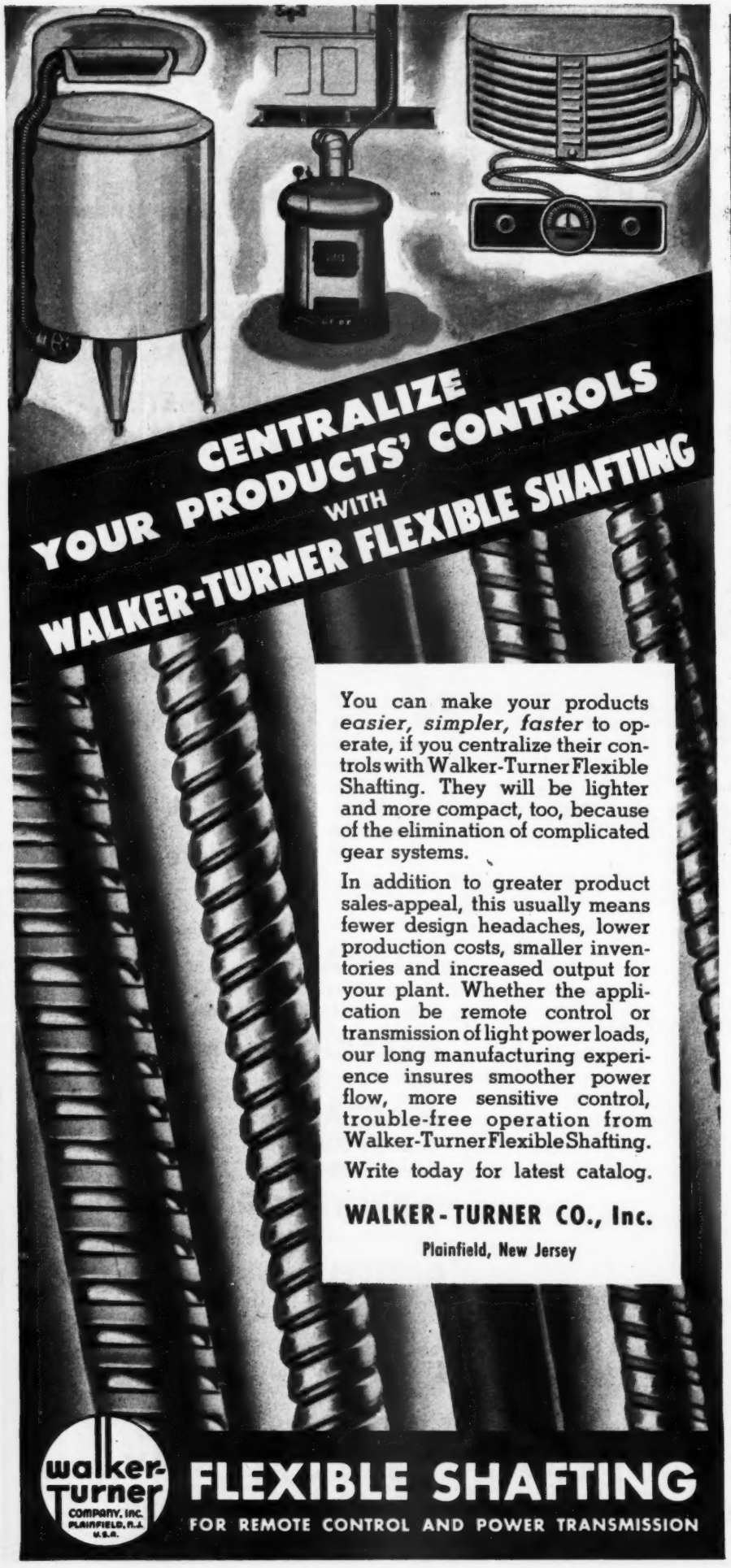
INDUCTANCE: (In Henries)
.035—14 .35—140 35—14,000

DECIBELS:
—10 to + 18 +10 to +38 +30 to +58

The Model 400 comes housed in a rugged crackle-finish steel cabinet complete with batteries, two sets of test leads, one set of V.T.V.M. probes and instructions. Size 5½"x9½"x10". Net.....

$52.50

SUPERIOR INSTRUMENTS COMPANY
DEPT. M., 227 FULTON STREET, NEW YORK 7, NEW YORK


CENTRALIZE
YOUR PRODUCTS' CONTROLS
WITH
WALKER-TURNER FLEXIBLE SHAFTING
You can make your products *easier, simpler, faster* to operate, if you centralize their controls with Walker-Turner Flexible Shafting. They will be lighter and more compact, too, because of the elimination of complicated gear systems.
In addition to greater product sales-appeal, this usually means fewer design headaches, lower production costs, smaller inventories and increased output for your plant. Whether the application be remote control or transmission of light power loads, our long manufacturing experience insures smoother power flow, more sensitive control, trouble-free operation from Walker-Turner Flexible Shafting.
Write today for latest catalog.
WALKER-TURNER CO., Inc.
Plainfield, New Jersey
walker-turner
COMPANY, INC.
PLAINFIELD, N.J.
U.S.A.
FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

rector at large for medium stations. T. A. M. Craven, WOL, had previously been elected as the other director-at-large for medium stations. Directors at large for small stations are Matthew H. Bonebrake, KOCY, and Clair R. McCollough, WGAL, while J. Leonard Reinsch, WSB, and J. Harold Ryan, WWVA, will serve as directors-at-large for large stations for the one-year term beginning July 1.

Two amendments to the by-laws have been approved, first to clarify the definition of large, small, and medium stations and second to broaden associate memberships.

Loudness of Common Words

WORKING ON RESEARCH aimed at helping individuals with impaired hearing, Dr. Harold Westlake of the speech and hearing clinic at Northwestern University discovered that the word "strawberry" is the most easily heard of the commonly-used words tested.

Next in order of audibility at low volume are "chicken", "oatmeal", "grandmother" and "soldier". The one hundredth word, which oddly enough was "squeak", had to be transmitted at nearly three times the loudness of "strawberry" before it could be understood.

For the test, each word was read into a microphone, reproduced by a loudspeaker in a separate soundproof room. A pre-amplifier and attenuator controlled the relative loudness of the signal. These word ratings will be used, for one thing, as a standardized test of hearing devices.

AIEE Officers

PRESIDENT OF THE American Institute of Electrical Engineers for the year beginning August 1 1945 is Dr. William E. Wickenden, president, Case School of Applied Science, Cleveland, Ohio. Other new officers announced are: vice-presidents—E. S. Fields, Cincinnati, Ohio; H. B. Wolf, Charlotte, N. C.; L. M. Robertson, Denver, Colo.; F. F. Evenson, San Diego, Calif.; F. L. Lawton, Montreal, Canada, directors—J. M. Flanigen, Atlanta, Ga.; J. R. North, Jackson, Mich.; and Walter C. Smith, San Francisco, Calif.

The annual report of the Insti-

A Tribute

to all those who helped in the greatest scientific achievement of all time... the

ATOMIC BOMB

"TO KEEP THE PEACE"

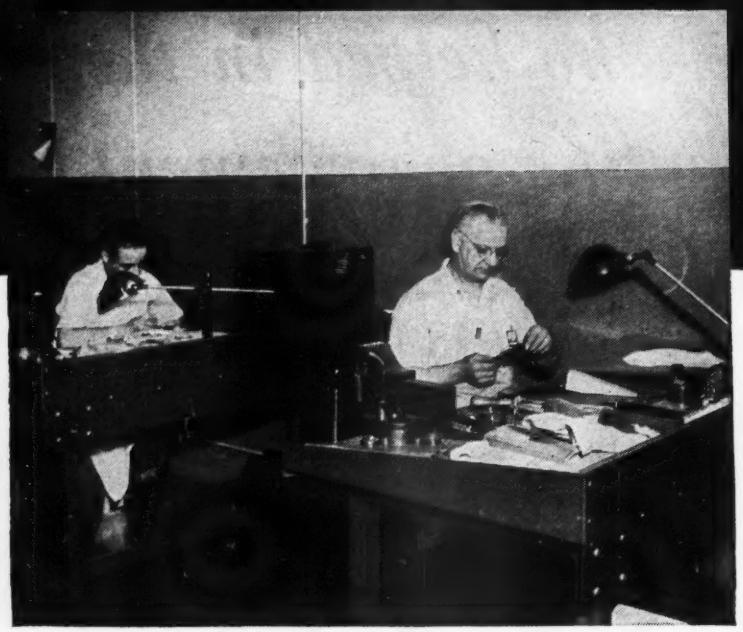
For the inspiration and leadership displayed by the Executive, Military, and Naval authorities... to the Scientists... Engineers... to Labor, and to those Companies that played a part in this unprecedented achievement, General Cable voices the sentiment of America in extending highest praise and heart-felt appreciation. Because of their scientific genius, their untiring effort and their complete devotion to this gigantic task, Victory comes sooner and all mankind benefits.

General Cable Corporation is also justly proud of the contribution made by its own staff in the engineering development and manufacture of still secret and exceedingly special materials essential in the production of this device of war... and of Peace.

GENERAL CABLE CORPORATION

MANUFACTURERS OF BARE AND INSULATED WIRES AND CABLES FOR EVERY ELECTRICAL PURPOSE

This may be your new
ELECTRICAL DEVELOPMENT DEPARTMENT



UNIONAIR'S manufacture of electrical assemblies to customers' specifications calls for the use of men with many specialized skills.

The photograph above shows precision hand workers laboriously and patiently building by hand the first working models of an electrical device. These models will be tested and approved before quantity production of the device is undertaken. Years of experience have proven to Unionair and its customers the wisdom of this step.

The time is fast growing closer when our organization will be able to turn from important war work to work for you. Write for our new booklet, titled, "Electrical Assemblies Made to Customers' Specifications," to: Union Aircraft Products Corp., 245 East 23rd Street, Dept. E, New York 10, N. Y.

ARMY NAVY

UNIONAIR

Electrical Assemblies—Hydraulic Fittings
Conduit Fittings—Junction Boxes

UNION AIRCRAFT PRODUCTS CORP., NEW YORK

tute showed a total membership of 23,072, and revealed that during the year besides three national technical meetings there had been 1,431 meetings held by local sections.

Airborne Electronics

BASED ON THE ESTIMATES of William A. Mara, the Bendix Aviation Corp. staff executive in charge of developments relating to the personal airplane, there will be a considerable market for radio and other airborne electronic equipment in the postwar period. This forecast predicts there will be a minimum of 3,500,000 licensed private fliers by 1960. Pointing out that this is a conservative estimate he declared that there would be a pool of some 6,000,000 active or potential fliers in the nation at the end of the war with a nucleus of 500,000 who have been trained to fly airplanes. These consist of 107,327 private pilots holding CAA licenses at the end of 1944; 25,000 licensed transport and commercial pilots; 159,000 pilots listed as trained by the AAF as of December 1944, and 47,000 pilots listed on the United States Navy roster as of December 1, 1944.

Including Scandinavia

AS A RESULT of special priorities assistance granted by WPB to the Norwegian government, the first direct radiotelephone communication between Norway and the United States is expected to open for public use late this year. Similar aid has been given France.

Census of Laboratories

NATIONAL RESEARCH Council is busy compiling the 8th edition of its directory "Industrial Research Laboratories in the United States." In the 7th edition, published in 1940, there were 2,264 companies who listed their industrial research laboratories, and the Council is eager to receive information concerning new laboratories which may have been founded since that time.

Research men are urged to inquire of their directors whether questionnaires have been received as those reporting in 1940 will have had their printed statements sent

LINE VOLTAGE INCREMENTAL CONTROL

SORENSEN

Announces

THE INCREVOLT

Sorensen and Company, Inc. offer a brand new idea in variable A.C. voltage controls. The INCREVOLT is a control capable of providing 0 to 130 volts in increments as small as 1/10 volt variation.

The current on Model 5 is 5 amps. maximum, and 15 amps. maximum on Model 15.

This outstanding control has the additional feature of "burn out" protection. The INCREVOLT is equipped with Klixon Thermostat protection, which provides absolute assurance against short circuits or overloads, which in the past caused many a burned out coil in the variable voltage transformer.

Model 5	Model 15
• 5 amps.	• 15 amps.
• 0-130 volts	• 0-130 volts

IT'S THE KNOW HOW THAT MAKES THE DIFFERENCE

SORENSEN & COMPANY, INC.

AIRBORNE ELECTRONICS — STAMFORD, CONN.

Permoflux Speakers and Transformers Set New Standards of Comparison!

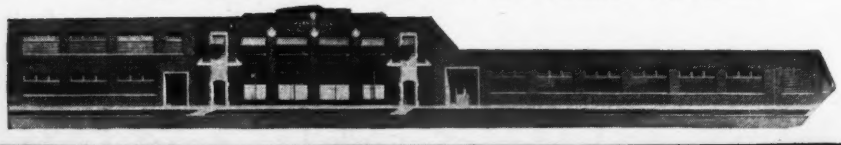
New Permoflux speakers in a complete range of true-dimensioned sizes from 2" to 15", with power handling capacities from 1 to 20 watts, provide the finest sound reproduction for every application.

Permoflux midget transformers, with their many practical circuit applications, have literally revolutionized efficiency concepts where size and weight are determining factors.

Advanced engineering designs, improved manufacturing methods and new materials have all contributed their share in the development of Permoflux speakers, transformers, microphones and headphones. You can count on Permoflux to provide an acoustical unit to suit your exacting requirements.

BUY WAR BONDS FOR VICTORY!

TRADE MARK
PERMOFLUX
PERMOFLUX CORPORATION
4900 WEST GRAND AVE., CHICAGO 39, ILL.



PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

for revision. If no questionnaire has arrived, one will be sent upon request to the Library, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. There is no charge nor obligation for inclusion in the listing.

Broader ASA

CHANGES HAVE BEEN made in the Constitution of the American Standards Association (ASA) which will remove restrictions confining its work to "those fields in which engineering methods apply". Thus, future standardization projects can be in any field which deserves national recognition. Other changes provide for specific mention of the consensus principle, by which all groups with an interest in a particular standard have the right to a voice in its development, and allow for election to the board of directors of three members-at-large. At present all but the ex-officio members of the board are nominated in rotation by the member bodies.

End of ABSIE

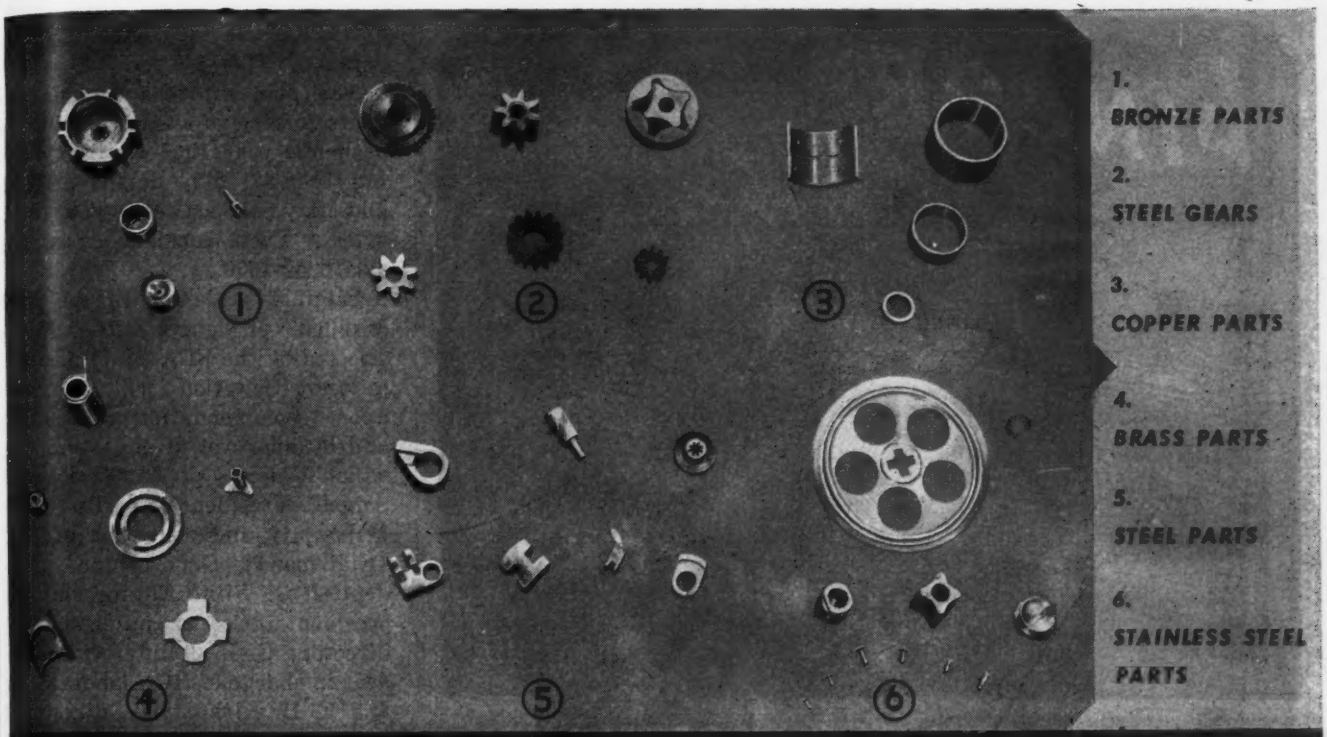
AT MIDNIGHT on July 4, the American Broadcasting Station in Europe (ABSIE) went off the air after fourteen months of continuous operation. Operated by OWI, the station developed a tremendous audience estimated at one time at 80 percent of the people of occupied Europe.

Berlin to America

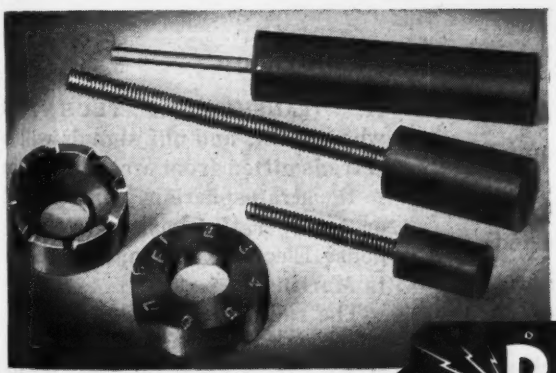
AT THE BEGINNING of July, Press Wireless began direct radiotelegraph service between Berlin and the Times Square control center in New York. The first message was one addressed to American Broadcasting Co., New York, from one of its correspondents, and was received at 300 words per minute. Handled through the mobile station PX, transmission is later to be extended to voice and radiophoto services.

RCA Scholarships

PROMISING YOUNG scientific students are to be encouraged by a scholarship plan adopted by Radio Corp. of America and recently announced by Brigadier General



MACHINE PARTS MADE BY POWDER METALLURGY...

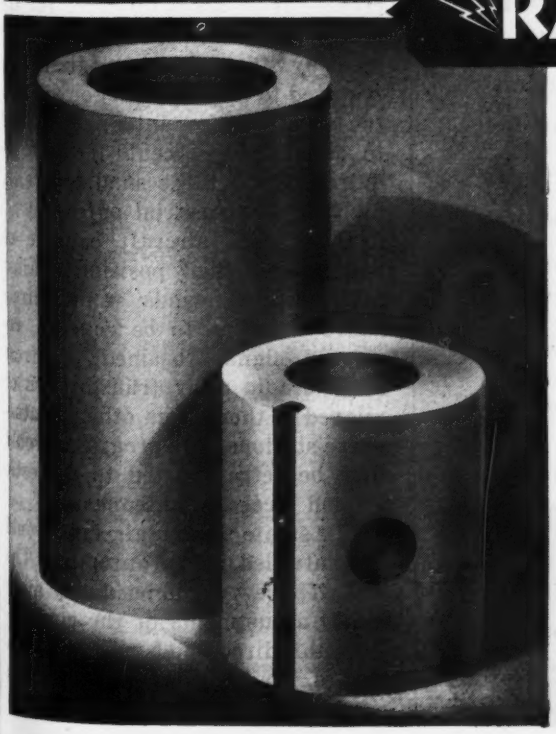


POWDER METALLURGY permits low cost, high volume production of close tolerance parts hitherto impossible by other methods. Other advantages include: maintaining high purity of metal content; obtaining a wide range of certain physical properties . . . with nominal material waste.

• • •

FOR YOUR POSTWAR NEEDS... High "Q", high permeability (appr. 30) Iron Cores for use from 400 KC to 2000 KC. **RADACOR** Iron Cores are also available in a wide variety of sizes, shapes and permeabilities for F.M. and television, in addition to our complete line of electronic cores.

RADACOR IRON CORES



ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART PRODUCTS DIVISION

MAGUIRE INDUSTRIES, INC.

375 Fairfield Avenue, Stamford, Conn.
Earl S. Patch, Sales Manager

Sales Representatives:
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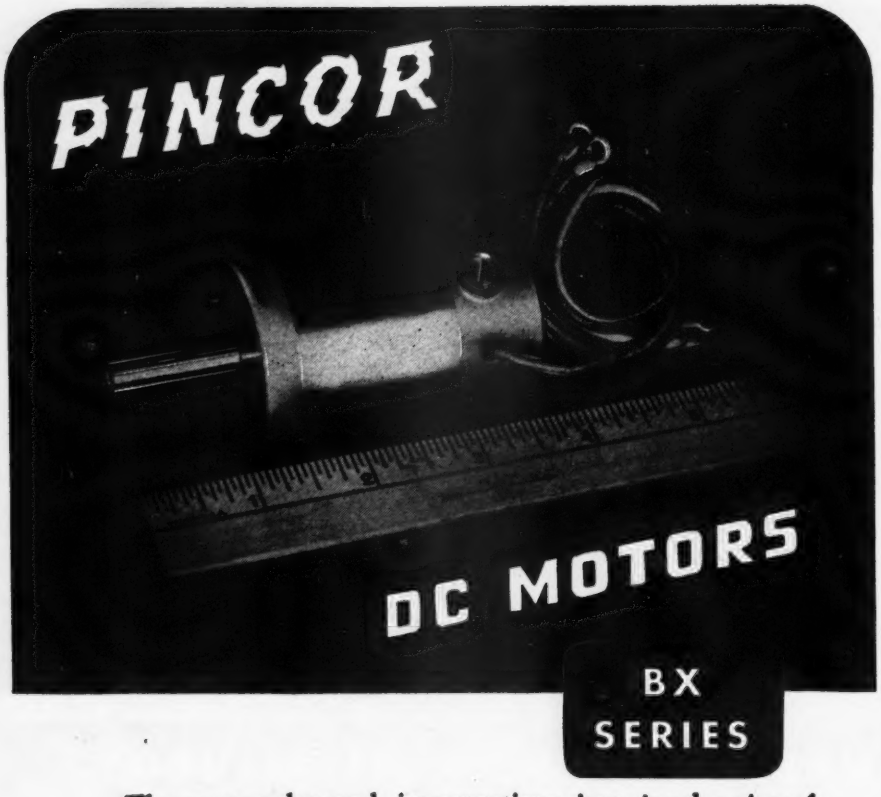
CHICAGO, ILL., 840 N. Michigan Ave., Ray E. Berg, E. C. Winkenwerder
INDIANAPOLIS, IND., 108 E. 9th St., Queisser Bros., Lee Hinds
JENKINTOWN, PA., P. O. Box 246, D. M. Hilliard
CANADA, 1041 Des Marchais Blvd. Verdun, Quebec, W. T. Hawes



The urgent demand, in peacetime days, by the aircraft and radio industries for a compact, efficient D.C. motor was the challenge that led Pioneer to develop the Pincor BX series. Today Pincor BX motors flow from our plant in a steady stream to the producers of aircraft and radio equipment for the armed services.

Pincor BX motors, in their classification, meet the varied requirements of aircraft and radio manufacturers that demand light weight, compact motors for efficient and dependable application. Pincor BX motors are direct drive, ball bearing, high speed units wound for continuous or intermittent duty. Shunt, series or split series windings are for operation on 12 to 24 volt battery systems currently used and may be easily modified to meet your product demand.

Depend on these rugged Pincor quality-proven motors in the BX series. Send your problem to Pioneer engineers and let them put their years of experience to work for you. Consultation with these men will not obligate you in the least.

DYNAMOTORS • CONVERTERS
GENERATORS
POWER PLANTS • GEN-E-MOTORS

PINCOR Products

PIONEER GEN-E-MOTOR
CORPORATION
5841-49 DICKENS AVENUE CHICAGO 39, ILLINOIS
Export Office: 25 Warren Street, New York 7, U.S.A.
Cable Address: Simontrice, N. Y.

BUY MORE BONDS!

David Sarnoff, the company's president.

The plan provides for ten students to receive awards during the academic year 1945-46, thirty during 1946-47, fifty during 1947-48, and sixty each academic year thereafter. Each consists of a cash award of $600.

Eligible students will be those enrolled at universities to be selected by the RCA education committee. Selection will be made upon recommendation of the dean and by approval of the committee, which consists of James Rowland Angell, president emeritus, Yale University and counselor of NBC (chairman); Gano Dunn, president, J. G. White Engineering Co., president of Cooper Union, and RCA director; C. B. Jolliffe, vice president in charge of RCA laboratories; and F. H. Kirkpatrick, director of education and training, RCA Victor Division.

Stratovision

A TRANSMISSION TECHNIQUE whereby vhf and uhf signals will be retransmitted from airplanes flying in the stratosphere is being planned on a cooperative basis by Westinghouse Electric Corp. and the Glenn L. Martin Co.

The radius of coverage of a television or f-m transmitter can be increased from about 50 miles for the terrestrial transmitter to about 200 miles by Stratovision, and the power required to cover the larger area by the stratosphere antenna reduced to about two percent of that required to cover the smaller area a number of terrestrial antennas.

Slow speed aircraft capable of maintaining their position against high altitude winds would circle above the area to be covered, receiving signals beamed up from small studio relay transmitters or relayed to them from other stratosphere stations. The programs would then be retransmitted to domestic ground receiving antennas.

The strato-station airplane would be controlled by an autopilot. The aircraft crew would need only make minor adjustments of the controls. The uhf directional relay antenna arrays would be kept focused on the circling aircraft by servo con-

Good companies settle here . . .

and stay!

Today, as always, Southern New England is the heart of the world's richest, most highly-concentrated market . . . the best of all reasons why industry should—and does—make this its home.

Draw a circle 500 miles from the center of Southern New England and you will include 58,000,000 consumers. Into that circle, Southern New England pours not only consumer goods but its producer commodities—machinery, tools, ball bearings—the parts and equipment that keep other industries going.

Beyond that circle looms the great world market of tomorrow . . . a market that will be served most efficiently by Southern New England's strategically located ports.

Southern New England has its personal appeal, too. For with its many delightful residential communities, its hills, lakes, and sandy beaches never more than a few miles from where you work, Southern New England is a great place to live and play.

As you weigh the future of your new or expanding business, consider Southern New England.

Search where you will, you won't find a more favorable spot . . . *anywhere.*

For your business and personal postwar planning, we offer an industrial booklet in full color: "Southern New England for Tomorrow's Industry". This booklet is yours for the asking. Write to P. E. Benjamin, Manager of Industrial Development, The New Haven Railroad, 80 Federal Street, Boston 10, Mass.

This is one of a series of advertisements presenting the industrial advantages of Southern New England.

THE NEW HAVEN R.R.

Serving **SOUTHERN NEW ENGLAND** *with a network of rail and highway transportation that puts every manufacturer* ON THE MAIN LINE.

Here's a soldering iron with . . .
HEAVY POWER
(225 WATTS)
LIGHT WEIGHT
(14 OUNCES)
made possible by
KWIKHEAT'S BUILT-IN THERMOSTAT
★ HEATS IN ONLY 90 SECONDS
★ MAINTAINS PROPER HEAT
★ CAN'T OVERHEAT
★ LESS RETINNING NEEDED
★ TIPS LAST LONGER
★ COOL, SAFE HANDLE
★ LIGHT WEIGHT
The Kwikheat Soldering Iron has ample reserve power for your soldering jobs—225 watts held in check by a thermostat built right into the iron*—maintaining ideal temperature for perfect soldering—preventing overheating (which causes deterioration in other irons)—prolonging life of tips and eliminating the need for constant retinning. Besides these big advantages, the Kwikheat Iron is hot, ready to use only 90 seconds after plugging in. It is extremely light (14 ounces), well-balanced, and has a safe, cool handle. No wonder Kwikheat is a sensation wherever it is used. Ask your jobber. With choice of #0, 1, 2, or 3 tips. $11.00
6 INTERCHANGEABLE TIP STYLES
#0 $1.25
#1 $1.25
#2 $1.25
#3 $1.25
#4 $1.75
#5 $1.25
*patented
VANATTA
kwikheat
THERMOSTATIC SOLDERING IRON
A Division of
Sound Equipment Corp. of Calif. • 3903 San Fernando Rd., Glendale 4, Calif.

trollers. There would be channels for four television and five f-m stations to operate through the Stratovision installation. Power for the radio equipment would be about four percent of the motive power for the airplane.

Because one airplane installation will cover so large an area, the operational cost of Stratovision will be one-thirteenth that of land based relay and transmission stations. Technical aspects have been solved in connection with other activities. As soon as production is available tests will be conducted.

Airway Pulse-Time Relay

PULSE-TIME MODULATION is to be used in a new u-h-f radio relay system which is the subject of an application to FCC by Federal Telephone & Radio Corp.

Connecting New York and Washington, this system would be used to supply coordinated information to the airways serving these cities. Ten relay stations would intervene. Frequencies requested are in the following ranges: 4,200 to 5,200 Mc, 1,225 to 1,325 Mc, and 7,000 to 8,500 Mc, with A2, A3, A4, A5 and special emission and 10 watts of power.

Safety Engineering Joins the Curriculum

NEW YORK UNIVERSITY has been given a grant of $8,000 by The National Safety Council to permit installation of safety engineering courses in the College of Engineering as an integral part of basic engineering training. A professorship will be established and all engineering laboratories and shops will be reorganized and reequipped so that they will incorporate true safety practices. Safety will not be offered as a specific course but will be integrated into all other courses of the school. The slogan will be "to make the embryo engineer unconsciously safety conscious."

Industrial Electronic Training Course

LECTURE MATERIAL consisting of sound-slide films, each approximately one-half hour long, review booklets with questions, and an in-

They wanted wire, tube and strip in Split-Hair Sizes

...and found the strong, corrosion-resistant metals they sought among the INCO Nickel Alloys

Are you looking for metals in ultra-fine sizes for essential applications today...or for your new products after the war?

Do you want... in addition to the split-hair size ... metals with strength, toughness and high resistance to corrosion?

Then take a look at these examples of how INCO Nickel Alloys can be produced in practically any form or size you may want for applications that need a rustless corrosion-resisting material with high mechanical properties...

THE WIRE shown in the magnified photo above knotted around two strands of human hair is 0.0009" thick. A pound would stretch 80 miles. It is a regular commercial product of the Driver-Harris Co.

THE TUBING, one of the smallest ever drawn, is compared with a mosquito's stinger. Outside diameter of this nickel tube is 0.0019"; inside diameter, 0.0004". (World's smallest metal tube, 0.0014" outside diameter, is also Nickel.) Superior Tube Company produces commercial tubing in INCO Nickel Alloys as small as 0.010", outside diameter.

THE STRIP is .00075" thick... one-third the thickness of this page. It would take more than 1300 strips to equal an inch. This nickel strip is made by Somers Brass Company for regular commercial use.

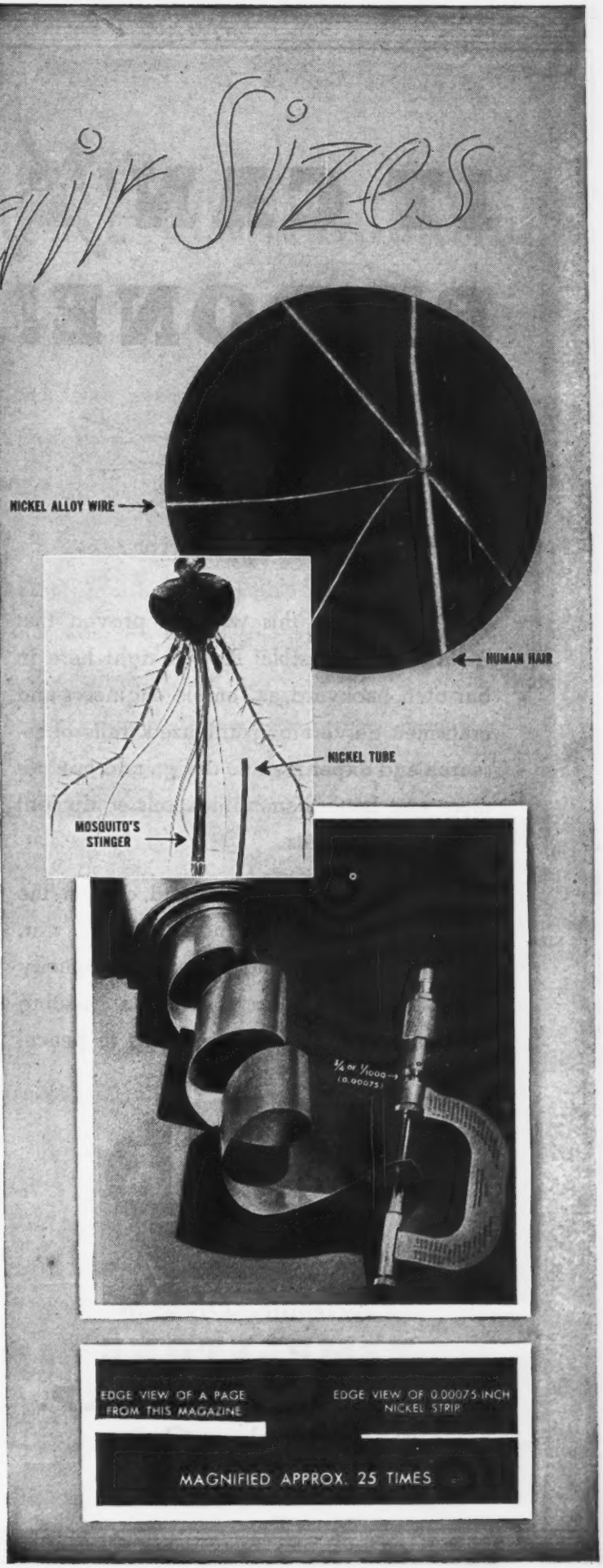
In addition to their group properties of high strength, toughness and corrosion resistance, individual INCO Nickel Alloys have *specialized* properties for applications requiring high-temperature strength, special hardness, resilience, etc.

"Tremendous Trifles" a booklet which discusses the properties, sizes and forms of 8 INCO Nickel Alloys will be sent to you on request. Please give Company, Name and Title. Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO NICKEL ALLOYS

Sheet... Strip... Rod... Tubing... Wire... Castings... Welding Rods



IT CAN'T BE DONE!

Time and again this war has proved that *nothing is impossible!* Proved right here in our own backyard, as Temple engineers and craftsmen delve along unblazed trails of research and experiment to design and *produce* more and better communications equipment for the battle fronts.

This ability to both design and deliver the seemingly impossible, under stress of war, has bred an unfailing inventive capacity that should prove invaluable in meeting the vast commercial requirements of peace.

Temple

Electronics Division

TEMPLETONE

RADIO MFG. CORP.

New London, Conn.

structor's guide form the basis of a twelve-lesson course in industrial electronics prepared by General Electric Co. All the materials fit in a durable carrying case.

Instruction includes a fundamental introduction to the electron, electron tubes used as rectifiers, grid control of electron tubes, two parts on fundamentals of electricity, electronic relay systems, electronic rectifier equipment, variable-speed motor control, electronic control of a-c power, electronic heating, photoelectric systems, and prospects for the future of electronics.

The entire course is priced at $100 with additional instructor's guides at $1 each and review booklets for $2 per set of 12. Information may be obtained from, or orders placed with General Electric Co. Schenectady 5, N. Y. or any G-E sales office.

Travelers' Aid by Radio

176 SPECIAL RADIO stations are slated to be installed throughout Argentina, operated under the direction of the Argentina Automobile Club, and controlled by post office authorities. Purpose of the system will be to transmit calls for assistance, data about weather or other development relating to highway or air travel, police and health messages, and dispatches in connection with movements of military organizations.

Other-American Radio

RESULTING FROM INFORMATION gathered by a questionnaire mailed to radio broadcast stations throughout Latin America, basic information on their operation has been published in book form by the Office of Inter-American Affairs and copies can be obtained free of charge from Kay Bailly, in the New York Office at 444 Madison Avenue.

While forms were sent to all stations, some were not returned and others were submitted in incomplete condition. The data has been listed just as received.

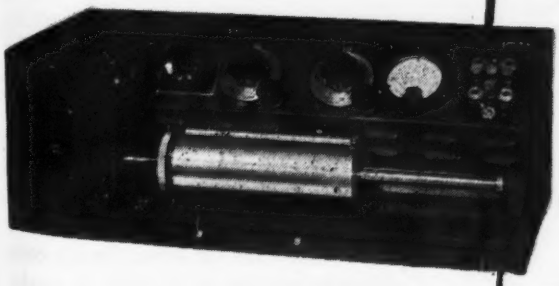
Details of the various stations include frequency, power, operating time, ownership, mechanical program equipment installed, and personnel. Additional features of the book include maps of the various countries, a time chart for the

1935
FACSIMILE COMMUNICATIONS
1945

Since 1935, the engineering staff of Times Telephoto Equipment Inc. and its predecessor company has been engaged exclusively in developing and producing facsimile communications equipment.

Times Telephoto's long experience in this new and revolutionary field of communications, its leadership in design and practical application, will be invaluable to the postwar user. These facsimile sets are used for sending and receiving written and printed matter, photographs and maps. They are standard equipment of the U. S. Signal Corps, Army Air Forces, Navy, the Office of War Information and some commercial companies and foreign governments.

When all military needs have been met, Times Telephoto Equipment Inc. will be ready to supply facsimile communications equipment especially designed to meet your particular requirements. Write today for your copy of the booklet, "Elements of Facsimile Communications."



HUNDREDS OF THIS MODEL ARE ALREADY IN SERVICE

TIMES TELEPHOTO EQUIPMENT INC.

A Subsidiary of The New York Times

229 West 43 Street — New York 18, N. Y.

Unusual and Vital
ELECTRONIC EQUIPMENT
PRODUCED BY
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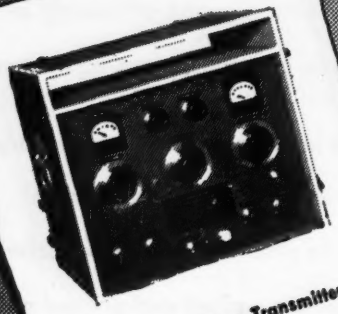
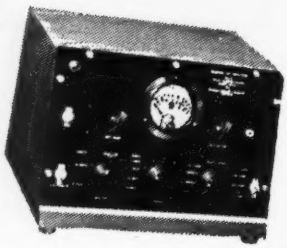
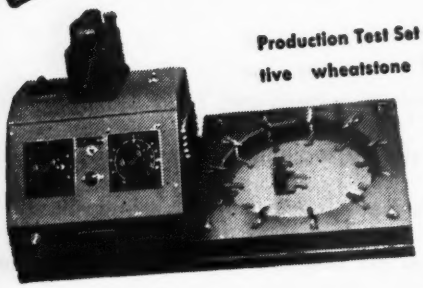
SUBCONTRACTING DEPT.



Special Short Wave Transmitter Range: 1-16 megacycles on one dial.



Development of special hearing aid analyzer for Western Electric Company.



Production Test Set to test varistors. A sensitive wheatstone bridge arranged with switching means for quickly checking a number of varistors in rapid sequence.

Manufacturers have continually called upon the modern facilities of Tech Lab Subcontracting Department to assist them in the production of unusual and vital electronic equipment. Our Engineering Department is ready to assist you with your production problems.

Carbon filling machines for precision filling of carbon microphones.

TECH LABORATORIES

MANUFACTURERS OF PRECISION ELECTRICAL RESISTANCE INSTRUMENTS

15 LINCOLN STREET, JERSEY CITY 7, N. J.

western hemisphere, exchange rate tables for the other American republics, summaries on numbers of radio stations and receivers, and network connections in the different countries.

MEETINGS TO COME

SEPT. 3; THIRD INTER-AMERICAN RADIO COMMUNICATIONS CONFERENCE, Rio de Janeiro, Brazil, Telecommunications Division, Ministry of Exterior Relations, Rio de Janeiro.

WASHINGTON NEWS

EASING OF CONTROLS. Modification in WPB orders revokes all restrictions on production of electronic equipment or subjects them to spot authorization procedure. Priority regulation 25 describes the revised method of getting authorization to make a product that is still restricted by limitation orders. All spot applications must be cleared with local production-urgency committee as well as with the Radio and Radar Industry Division in Washington to establish that the contemplated production will not interfere with military programs.

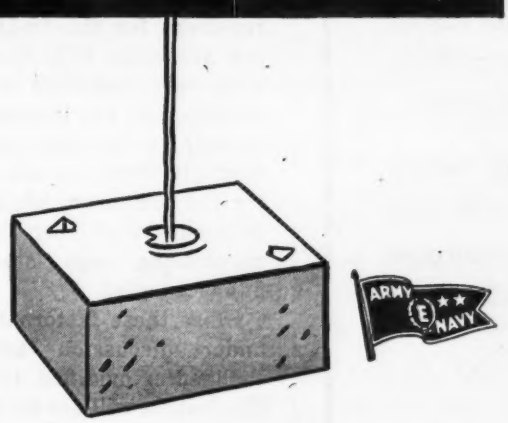
Among the items eliminated from coverage of the general limitation order L-265 are certain items that do not require electronic components and are not generally produced on facilities now being used for electronic equipment. Among these are radio antennas, recording blanks, and spring-motor acoustic phonographs.

Among materials whose controls have been relaxed are the smaller sizes of mica of all qualities, formal authorization no longer being required for use in sizes smaller than grade 4. At the same time, Madagascar mica, previously reserved for purchase only by United Nation governments is now available to private importers. Production, distribution, and sale of transformers, capacitors or other radio components, designed for use in equipment not involving the use of vacuum or gaseous tubes, or designed for use in equipment specifically excluded from order L-265 are not subject to controls.

Restrictions have also been removed from complete sets of electronic equipment as well as the following components: coaxial cable,

MEASURE HIM CAREFULLY...

ITEM		GOOD COMMERCIAL TOLERANCE
CAST DIMENSIONS	LESS THAN 1"	$\pm \frac{1}{64}$"
	1" - 4"	$\pm \frac{1}{32}$"
FINISH GROUND DIMENSIONS (PLANE SURFACES)		±.005"
PARALLELISM BETWEEN GROUND PARALLEL FACES		.002"/LINEAR INCH ACROSS FACE
PERPENDICULARITY	BETWEEN GROUND FACE AND CENTER PLANE OF AS CAST MAGNET	$\frac{1}{2}$°
	BETWEEN TWO GROUND FACES	$\frac{1}{2}$°
CASTING DRAFT		1°
GRINDING ALLOWANCE		RULE: .015"/1.5 SQUARE INCHES OF EACH SURFACE TO BE GROUND.



He's no Beau Brummell, this rough and ready permanent magnet but when he's measured up for casting, he's just as fussy about the length and girth of his trousers and about the fit of the coat Give him a suit that's too baggy or skin-tight and he won't be able to do his best work.

Casting tolerances for the ALNICOS are important to know when designing permanent magnets. Certain latitude is permissible but to stray beyond practical limits is to invite trouble. Many years of experience in designing and casting ALNICO Magnets have taught us much about casting tolerances. Our ideas are summarized in the chart shown at the left and discussed in detail in our pamphlet PERMANENT MAGNET DESIGN. If you are designing your own magnets you should have this information handy. We'll be glad to send you a copy.

9-CC-1

CINAUDAGRAPH CORPORATION

2 SELLECK STREET STAMFORD, CONNECTICUT

1200 WORDS *per minute!*

Extraordinary — but true! Mecanitron has made new history in communications! This proven performance recorder equipped for either on-off keying or frequency shift reception may be used alone for code transcription at any speed or in connection with teletype transmitting and receiving terminal equipment for translation into the printed word.

Constructed for all speeds; because of its clear, accurate reception at 1200 w.p.m., Mecanitron does a superb job at ordinary and low speeds.

Pulse amplifier output response constant when input power varies between —5 db to +25 db; input impedance 500 ohms; operating voltage ranges 110-120 volts A.C. at 50-60 cycles, 220 volts A.C. at 25-50-60 cycles.

For further details, write to

MECANITRON CORPORATION
711 Boylston St., Boston 16, Mass., U.S.A.

hermetically sealed and other tran formers and reactors, oil-impre nated power factor and mold bakelite capacitors, and wire-wou resistors. These changes we provided in an amendment to Pr orities Regulation 13. Also, th number of restricted radio an radar tubes was changed by th removal of four tubes from the li and the addition of seven, making total of 23.

EDUCATIONAL BROADCASTS. Unde the auspices of FCC, a three-da meeting was recently held in Was ington by educators representin schools throughout the countr The objective was to plan wit SPB (Surplus Property Board) th utilization of surplus radio an electronic equipment in fosterin and expanding educational pro grams. The gathering envisione an ultimate system of more tha 800 broadcasting stations devote exclusively to educational pursuit Other factors considered were th possibility of using surplus equip ment and components for study i classroom and laboratory as well.

FCC REGULATIONS. Section 6.11 o the FCC rules governing fixed pub lic radio service has been amende to permit use of A-3 emission fo the following purposes: transmis sion of addressed program mate rial, as set forth in section 6.51 controlling the transmission and re ception of addressed program mate rial, and controlling the transmis sion and reception of facsimile ma terial. Changes have also bee made in the requirements for peri odical reports of frequencies use and points serviced.

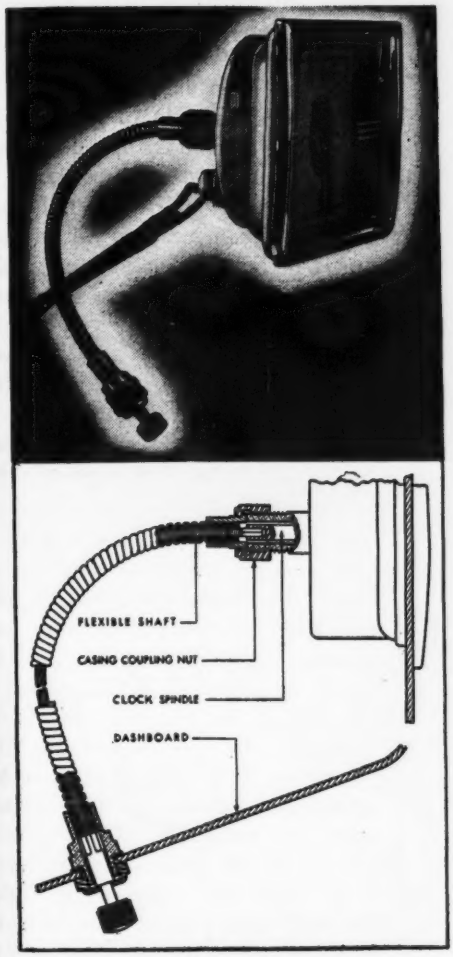
INTERIM F-M. Until the time when receivers for the 88-106 mc band are available, FCC is encouragin temporary operation in both bands Accordingly, any licensee wishing t operate in the new band may in formally apply to the Commissio for the temporary assignment of a frequency until such time as rules regulations and standards are finally adopted.

Since these factors are currently under discussion and may be changed or modified, temporary au thorization will not be a determina tion of coverage, power, or other factors relating to the assignment that existing stations will eventu ally be given. Requests for tem

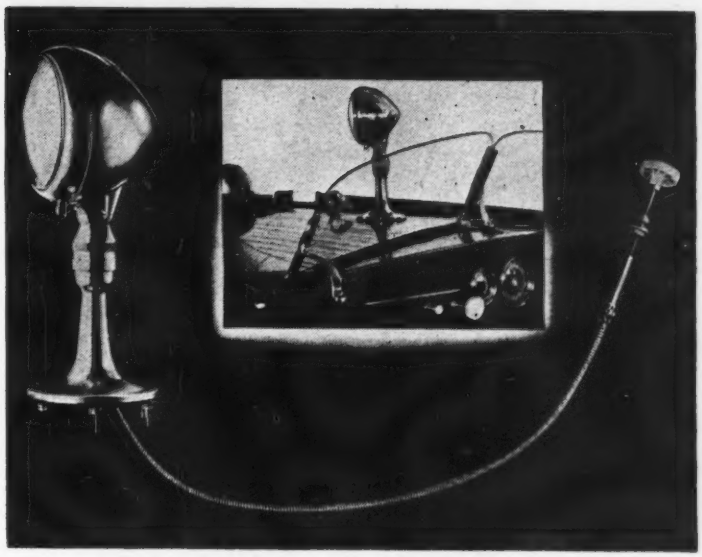
Here's a simple way to provide

COMBINED PUSH-PULL AND ROTATIONAL REMOTE CONTROL

Remote control of elements requiring push-pull as well as rotation, can readily be accomplished with a single S. S. White Remote Control Flexible Shaft. Two examples are illustrated. Designers of electronic equipment may find occasion to use this simple solution to the problem of combined push-pull and rotational remote control.



This Automobile Clock is set by pushing in the clock spindle to disengage it from the mechanism and then turning. The sketch shows how both the push-pull and rotation are obtained with a flexible shaft from a convenient point under the dash. A similar arrangement is used on speedometers for resetting trip mileage.



This Marine Spot Light is rotated horizontally by turning the control knob of the flexible shaft remote control, and is tilted up by pulling the knob out, and tilted down by pushing it in. A similar arrangement is used on automobile spot lights.

Send for This 256-Page Flexible Shaft Handbook

This book fully covers the subject of flexible shafts. It gives all essential engineering data on both power drive and remote control shafts and explains how to select and apply them for specific requirements. A complimentary copy will be mailed if you will write for it on your business letterhead and indicate your position.

ARMY E NAVY

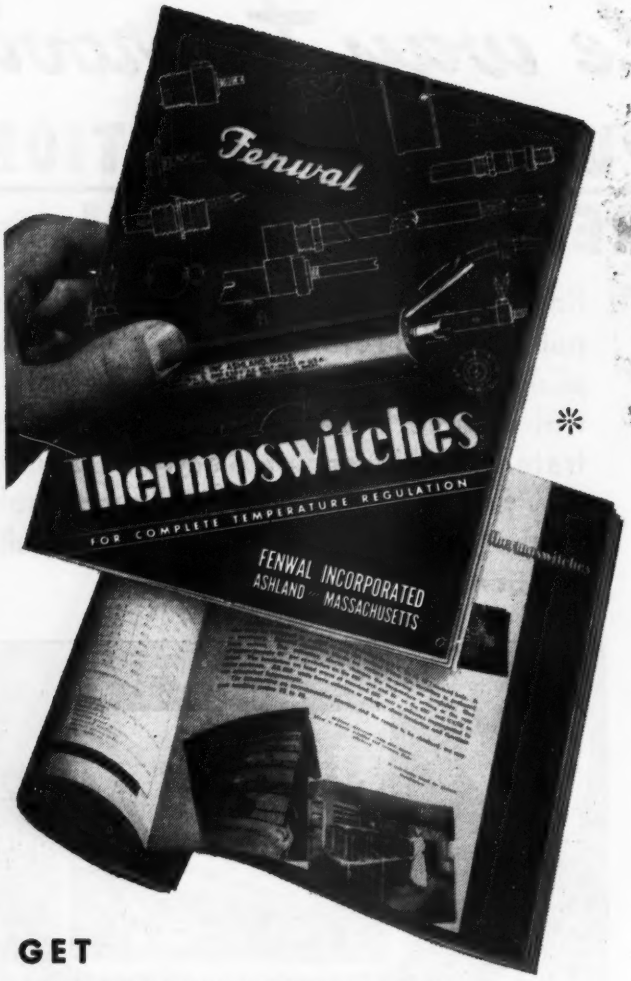
S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises



GET THIS VALUABLE BOOK On Temperature Control

Mailed to you without obligation immediately

TO AIRCRAFT DEVELOPMENT ENGINEERS

Before deciding on temperature regulating devices for your products, be sure to investigate Fenwal Thermoswitches. They operate on an unusual principle, and offer many advantages not found in other types of switches. The Fenwal Engineering Data Book contains detailed drawings of construction of various models and typical installations.

- Compact construction permits installation in tight places.
- Make and break unaffected by external vibration.
- Readily adjustable for wide range of temperature control.
- Minutely accurate.
- Adaptable for all types of media.
- Inexpensive.

• A 44-page treatise on Thermal Control including installation drawings, photographs, blueprints and descriptive suggestions for future planning with basic principles involved in temperature regulation and control. . . . Just write for your *free* copy on your business letterhead.

"IF IT'S A FENWAL—IT'S THE BEST OF ALL"

THERMOSWITCHES
Fenwal, Inc.
FOR COMPLETE TEMPERATURE CONTROL
48 Pleasant Street, Ashland, Massachusetts

porary operation of this type should include a description of the proposed transmitting equipment, output power, antenna system, and monitoring equipment or methods. Special authorizations will be issued for 90-day periods by the chief engineer.

The Commission also points out that the 42-50 mc band will be closed as soon as f-m receivers are generally available to cover 88-106 mc. This will make it unnecessary to build new receivers covering the 42-50 mc region. However, because it will not be necessary for an existing f-m licensee to give up a frequency in the 44-50 mc band until a television station is authorized to operate in it, it is considered likely that few f-m stations will find it necessary to make an interim move to the 42-44 mc band suggested in the Commission's final allocation report.

BROADCAST POWER. After Sept. 1, full power operation will be optional as a result of a recent order by FCC affecting broadcast stations. After October 1 it will become mandatory. Dating back to November 6 1942, the one-decibel power cut is restored because WPB informed FCC that materials and equipment for transmitters are now generally available. The operation of standard broadcast stations with full power is in the public interest, and opportunity should be afforded for making the necessary readjustments and tests to return to normal operating practices.

Also, since materials and equipment are now available to a-m stations for construction of most facilities required by FCC's standard of good engineering practice, FCC will require that licensees who have been permitted to operate without fully conforming to standards because of the scarcity of materials must now make application for the necessary improvements.

BUSINESS NEWS

PACKARD-BELL CO. is expanding into the E. L. Cord Building at 3443 Wilshire Blvd., Los Angeles, Calif. Simultaneously, the company's engineering department will include a research division.

SONORA RADIO & TELEVISION CORP., Chicago, Ill., acquires the Sterling Wood Manufacturing Co. to pro-

more efficient ...in miniature

ACTUAL SIZE

To clean and generally maintain the bulky, smelly oil lamp was a daily chore. In contrast, the compact incandescent lamp that gives many times the light, requires no maintenance except a rare and easily installed replacement. Its operation is safe and simple.

Just as the incandescent lamp opened up new avenues for more efficient lighting, so the miniature electronic tube presents new possibilities in the science of electronics. More compact sets—greater durability because of small rugged parts and better performance when used in high frequency circuits, are advantages of using Tung-Sol Miniature Tubes.

Manufacturers of radio sets and other electronic devices are invited to study the advisability of using miniatures in their new equipment. Tung-Sol Engineers would be glad to aid them in designing circuits and selecting tubes. All plans that are disclosed in consultation are held in strictest confidence.

TUNG-SOL

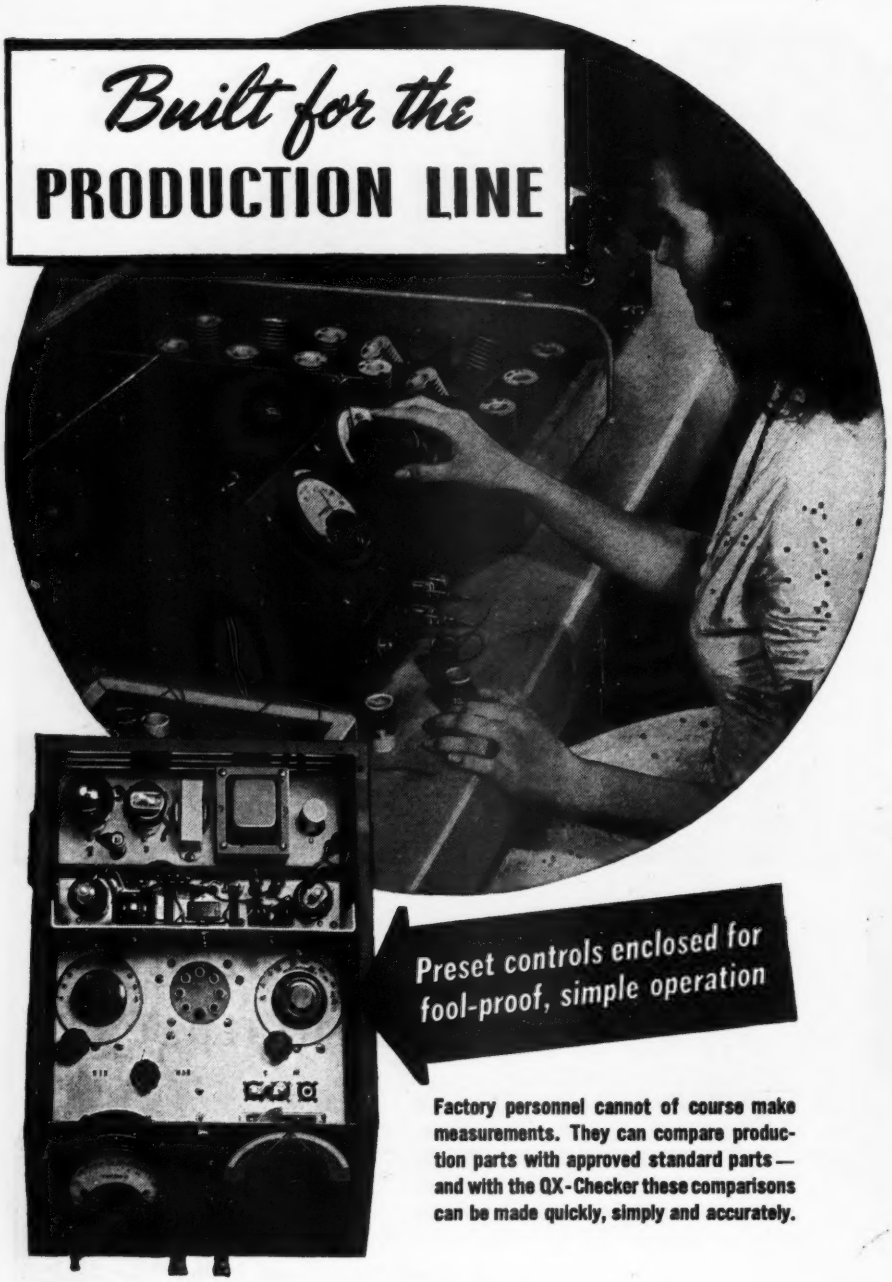
vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

Built for the PRODUCTION LINE



Preset controls enclosed for fool-proof, simple operation

Factory personnel cannot of course make measurements. They can compare production parts with approved standard parts — and with the QX-Checker these comparisons can be made quickly, simply and accurately.

QX-CHECKER *TYPE 110-A*

The QX-Checker is specifically designed for production use to check both the reactance and resistance of any R.F. component. These properties are simultaneously indicated when a component is resonated in a tuned circuit. The two factors, reactance and resistance, are separately indicated, one on the condenser dial, the other on the meter so that the deviation of either from established tolerances is immediately shown. Insures uniform parts held within close tolerances. Frequency range 100 kc. to 25 mc.

For further information, write for catalog "C"

BOONTON RADIO Corporation

BOONTON, N. J.

DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS

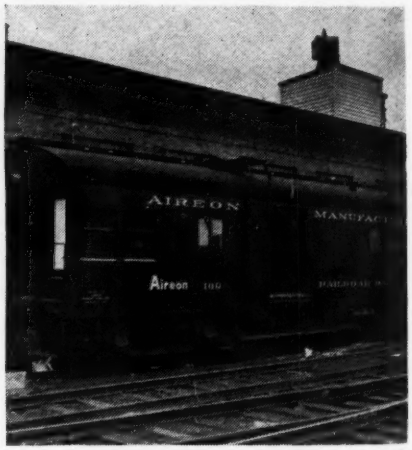
duce radio cabinets, the Rek-O-Plastik Co. to manufacture phonograph records, and the Electronic Parts Mfg. Co. to produce scarce components.

CROSLEY CORP., including station WLW in Cincinnati and other broadcast facilities, has been sold to Aviation Corp.

WIRE RECORDER DEVELOPMENT CORP. is expanding into larger space in the Field Building, 135 South La Salle St., Chicago, Ill. The new quarters will contain a studio for demonstration work.

WESTINGHOUSE ELECTRIC CORP., Pittsburgh, Pa. has just made its largest ($3,063) production-suggestion award to a retired real estate operator working in the Bloomfield plant. The suggestion has reduced by 62 percent the quantity of gold alloy wire required to solder electronic tube parts.

AIREON MFG. CORP. has purchased and equipped a special railroad car



to be used in the demonstration, test, and installation of their railroad radiotelephones.

RADIO CORP. OF AMERICA has concluded a new agreement with N. V. Philips' Gloeilampenfabrieken of Eindhoven, Holland, to permit continuation of licensing other manufacturers under the latter company's U. S. patents.

MAGUIRE INDUSTRIES, INC. merges the Ferrocart Corp. and Micro Products Corp. into a new powder metallurgy division. Both operations have been moved to 375 Fairfield Ave., Stamford, Conn.

REEVES-ELY LABORATORIES, New York, N. Y., has consolidated its

...by Revere
increases electronic production

To meet the demands of the electronic and electrical industries, Revere now offers Revere Free-Cutting Copper Rod.

This is oxygen-free, high conductivity copper containing a small amount of tellurium. This, plus special processing in the Revere mills, greatly increases the speed with which the metal can be machined, makes it possible to hold closer tolerances, improves the finish of completed parts, lessens rejects, cuts costs.

Revere Free-Cutting Copper Rod already has proved invaluable for the precision manufacture of certain interior vacuum tube parts that must be made to exceptional standards. However, it does not make a vacuum-tight seal with glass, and OFHC copper or other metals and alloys must continue to be used for that purpose. The rod is available in sizes up to 2" and in all the usual shapes.

The Revere Technical Advisory Service has worked out solutions of a number of difficulties encountered with the use of copper and its alloys in electronics. May we collaborate on your problems?

Listen to The Human Adventure *on the Mutual Network every Wednesday evening, 10 to 10:30 p.m., EWT*

CUSTOMERS REPORT:

"This material seems to machine much better than our previous hard copper bar; it cuts off smoothly, takes a very nice thread, and does not clog the die." (Electrical parts.)

"Increased feed from 1½" to 6" per minute and do five at one time instead of two." (Switch parts.)

"Spindle speed increased from 924 to 1161 RPM and feed from .0065" to .0105" per spindle revolution. This resulted in a decrease in the time required to produce the part from .0063 hours to .0036 hours. Material was capable of faster machine speeds but machine was turning over at its maximum. Chips cleared tools freely, operator did not have to remove by hand." (Disconnect studs.)

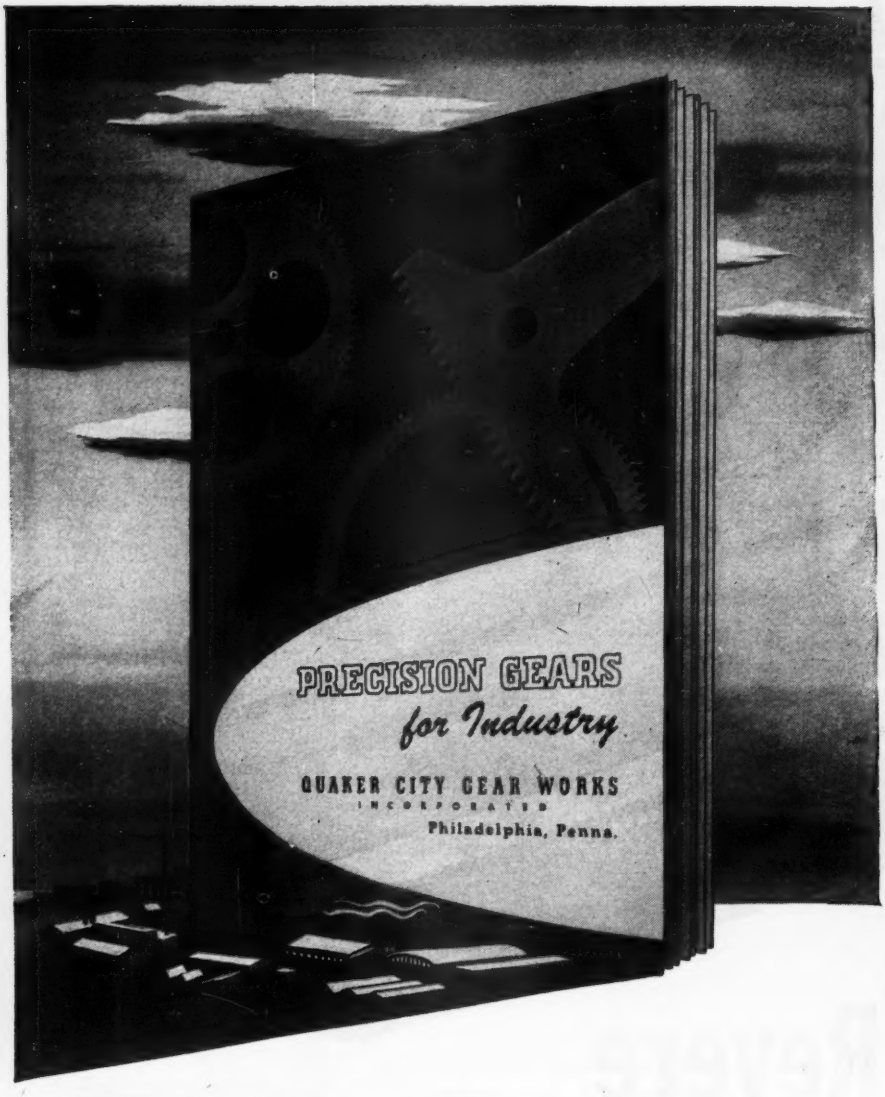
REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y. — Sales Offices in principal cities, distributors everywhere



Yours for the asking

A new informative booklet on gears. It has illustrated sections **on practically every known form of gearing, together with** **many reference tables and formulas. Write for your copy today on your company stationery.**

Quaker City Gear Works
INCORPORATED

1910 N. Front Street, Philadelphia 22, Pa.

various subsidiary companies and operating divisions. Now housed in 15 buildings in three states are Reeves Sound Laboratories, Hudson American Corp., American Transformer Co., Winsted Hardware Mfg. Co., and Waring Products Corp.

GENERAL ELECTRIC Co. has demonstrated a model of their postwar large-screen television receiver, giving a 16 × 22 in. picture. Shown at the same time was a new combination radio-phonograph incor-

porating an advanced design but still in tentative form because improvements are expected. In the accompanying illustration, the television receiver is shown delivering a special WNBT program put on for the purpose.

HALLICRAFTERS Co., Chicago, Ill., hopes, with the assistance of spot authorization, to manufacture 250,000 f-m converters, permitting reception on prewar f-m receivers of transmissions in the new 88-106 mc band.

BENDIX AVIATION CORP. establishes a separate engineering and sales organization to coordinate development, manufacture, and marketing of low-cost radio communications and avigation equipment for personal airplanes. It comes under the Bendix Radio Division.

FRANK H. MCINTOSH, consulting radio engineer, is now located at 710 Fourteenth St., N.W., Washington 5, D. C.

PERMOFLUX CORP. has enlarged its manufacturing headquarters in Chicago to provide increased space

OFFICIAL U. S. NAVY PHOTO

Any port in a storm ... but there are no ports

More than one sailor has said, "It's a helluva place to fight a war!"

That's a miracle of understatement when you know the Pacific as well as the U. S. Navy knows it.

They know how many thousands of miles you have to go before you reach the fighting fronts.

They know there's almost continual rain and bad weather to hamper operations after you get there.

And they know there are no good ports!

Think of the thousands of ships, and the millions of tons of supplies it takes to keep our fighting forces moving toward Japan.

Imagine, if you can, the problem of handling those ships and supplies with no port facilities.

There are no giant cargo cranes... no miles of docks and warehouses...nothing but beaches, and human backs, and a refusal to call any job impossible.

Remember, too:

It takes 3 ships to do the supply job in the Pacific that 1 ship can do in the Atlantic.

It takes 6 to 11 tons of supplies to put a man on the Pacific battleline, and another ton per month to keep him supplied.

It takes a supply vessel, under ideal conditions, half a year to make one round trip.

Add up those facts, multiply by the number of sailors, soldiers, and marines for whom the Navy is responsible.

Maybe you'll begin to realize what "no ports" can mean in the rough, tough waters of the Pacific.

Maybe you'll see that we have *two* reasons to be proud of the U. S. Navy. *First,* the way they've sunk the enemy's ships.

Second, the way they sail *your* ships ... taking the worst the Pacific can hand them... but keeping the supply lines open ...keeping the attack *on schedule!*

SPERRY GYROSCOPE COMPANY, INC. GREAT NECK, N. Y.

★

Division of the Sperry Corporation

LOS ANGELES • SAN FRANCISCO • SEATTLE • NEW ORLEANS
CLEVELAND • BROOKLYN • HONOLULU

MAKERS OF PRECISION INSTRUMENTS FOR THE ARMED FORCES

HIGHLY ACCURATE, STABLE VT VOLTMETER

features WAR RESTRICTED DEVELOPMENTS!

TELEVISO, pioneering in the production of measuring apparatus for the SONIC to UHF SPECTRUM, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:—

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usuable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the fi ld. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

Televiso Products Inc.

7466 IRVING PARK ROAD CHICAGO 34, ILLINOIS

for production, engineering, and research.

DEMUTH GLASS WORKS INC., Brooklyn, N. Y., has been taken over by Foster-Forbes Glass Co., Marion, Ind. The company manufactures electron tube envelopes, besides other glass products.

TOTH & LORBER is the name of a new firm of engineering consultants consisting of Albert F. Toth and John F. Lorber and located at 38 Park Row, New York 7, N. Y. Specialties will include industrial electronics, communication, television, radio, and acoustics.

UNION PACIFIC RAILROAD has started electronic classes for company electricians in five cities through the road's 11-state territory. In many cases instruction is handled by Marquette-University-trained union leaders.

GENERAL TELEVISION & RADIO CORP., Chicago, Ill., has purchased the building at 2701 Lehmann St. formerly occupied by Press Wireless. A one-story structure with over 30,000 sq ft of space, it will house the factory and executive offices.

PERSONNEL

ARTHUR J. SANIAL becomes chief engineer of Atlas Sound Corp., Brooklyn, N. Y. He comes from the sound systems department of the Fox Film Corp.

ROYAL V. HOWARD, back from overseas duty with the U. S. Army, becomes vice-president in charge of engineering for Associated Broadcasters Inc. and the Universal Broadcasting Co. of San Francisco, Calif.

CHRISTIAN A. VOLF becomes director of research in the electronic and acoustic division of Robinson-Houchin Optical Co., Columbus, Ohio.

O. S. DUFFENDACK, director of research, North American Phillips Co., New York, N. Y., is appointed vice president and director of research and engineering.

GLENN E. WEBSTER goes from engineering supervisor in the Chicago office of NBC to join the engineering staff of Collins Radio Co. Cedar Rapids, Iowa. He will be in

Boost radio sales with

built-in Telechron Selectors

HERE'S a double-duty timer to give your radio receivers the *extra* appeal needed for successful post-war selling. It's *much more* than an absolutely accurate electric clock. It turns on the set automatically at any pre-selected time in the morning to waken the owner with music. It switches the set on for favorite programs during the day and evening—then shuts it off at bedtime.

The cost to set makers is remarkably small—less than $4. Installation expense is low, too. Volume producers are already choosing it for moderate-price sets.

Radio listeners will like the Telechron Selector's easy finger-tip control. There are no knobs to turn and no difficult calculations. Programs are selected for any 15-minute period by flipping out one of the 48 keys around the large, legible clock dial. Keys are automatically reset to "off" position after timing periods are passed. Programs can be selected 10 hours in advance.

The C-28 Telechron Selector is only one of the full line of automatic timing and control devices we can supply for the sets you're now building or planning. *All use famed Telechron movements and self-starting synchronous motors for accuracy, dependability and long life.*

For full information about the C-28 Selector and other Telechron timers, wire or write Automatic Control Division, Dept. K.

Telechron

REG. U. S. PAT. OFF.

WARREN TELECHRON COMPANY • ASHLAND, MASSACHUSETTS

Available NOW!

VHF RECEIVER KIT
with New FM Band

88.6 to 107.6 Mc **115 to 140 Mc**

ACORN TUBES • SEPARATE TUNING UNIT

Ideal for Communications Work, Instruction, Training, etc.

A unique 10 tube Concord Kit for FM-AM and VHF reception with a separate tuning unit employing the new acorn tubes. Circuit design is straightforward and simple with no frills or unnecessary components. Extremely compact, sturdy and easily assembled. Has only two controls on the front panel—the tuning control and the volume control. There's a standard headphone jack for output, a switch for changeover from FM to AM, and a power switch in the AC line.

Comes complete with all necessary parts including holes punched and all tubes, wire, solder, hardware, and detailed instructions. Chassis is 10″ x 12″ x 3″ black finish. Dull black panel is 6¼ x 12″ wide. Two models—CRC-130—Range 88.6 to 107.6 Mc (for the new FM Band), and CRC-140—Range 115 to 140 Mc. Quantity limited—while they last —Use coupon below to order today or to ask for literature giving detailed information and specifications.

Complete with Tubes **$54.95**

CONCORD RADIO CORP.
LAFAYETTE RADIO CORPORATION
CHICAGO 7, ILL. 901 W. Jackson Blvd. • ATLANTA 3, GA. 265 Peachtree St.

CONCORD RADIO CORP.
901 W. Jackson Blvd., Dept. G-95, Chicago 7, Ill.
Please ship at once the Concord VHF Receiver Kit—or special descriptive literature—as checked below.

☐ CRC-130—VHF Kit Range 88.6 to 107.6 Mc ☐ CRC-140—VHF Kit Range 115 to 140 Mc ☐ Send literature giving details and specifications

Name.....

Address.....

City.....*State*.....

charge of development in broadcast speech input and associated equipment.

P. B. HARWOOD is elected vice-president in charge of engineering of Cutler-Hammer, Milwaukee, Wis.

ROBERT W. CLARK, former WEAF station engineer, becomes television operations supervisor at NBC New York, N. Y.

JEAN M. ROBERTS, formerly senior research and development engineer at Lear, Inc., becomes chief engineer of Associated Electronics Corp., New York, N. Y.

E. H. SCOTT, founder and president of the company, resigns as head of E. H. Scott Radio Laboratories, Chicago, Ill.

RAY ELLIS, FEA consultant and former director of the WPB Radio-Radar Division, is chairman of a governmental committee studying German electronics. Other members include Ralph Bown, Bell Laboratories; present Radio-Radar Division Director, L. J. Chatten; Captain F. C. Layne of the Navy Electronics Division; Captain Gilbert Myers, USN, Secretary of Joint Communications Board; and Brigadier General T. C. Rives, deputy Air Communications Officer, AAF Hq.

JENNINGS B. DOW, director of the Electronics Division in the Navy

Bureau of Ships, has been promoted from Captain to Commodore.

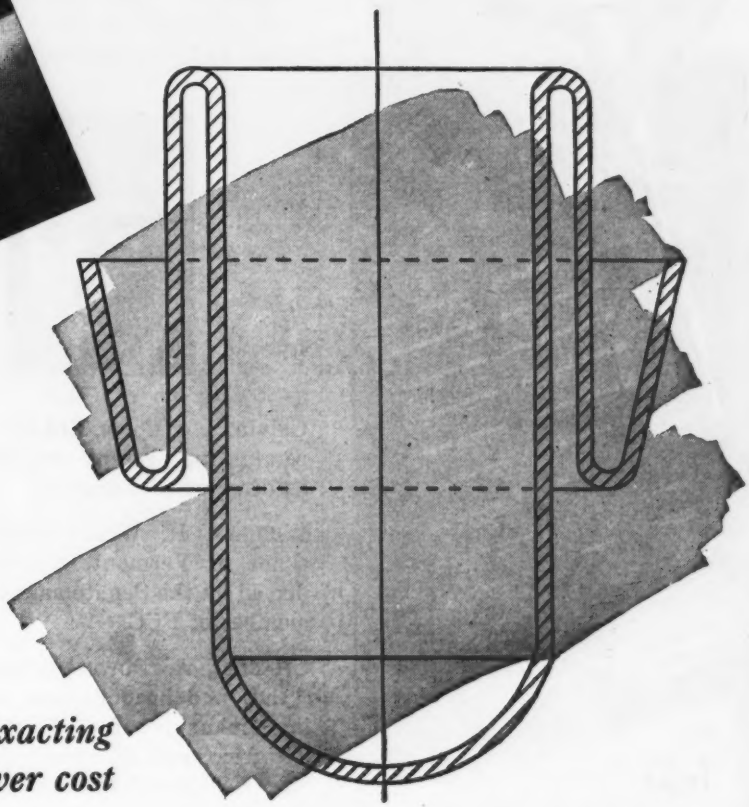
GARRARD MOUNTJOY, who has been in charge of research and development in the Radio Division of Lear Inc., has been advanced to take charge of all research and development in the New York laboratories.

F. F. SYLVESTER becomes technical director of Reeves-Ely Laboratories. Previously with Lewyt Corp., he will be in charge of research and engineering.

JOHN T. TATE, division chief, Na-

SCOVILL DEVISED A NEW SCHEDULE FOR TRANSMITTER TUBE ANODES

. . . and put them on the air faster



How Scovill Electronents meet exacting specifications . . . often at lower cost*

This anode for a radio broadcasting tube involved several difficult problems. Specifications called for a seamless, one-piece, pure oxygen-free copper shell . . . free from imperfections. Dimensions: length 6 41/64", I.D. 3", diameter across hollow flanged section 5 61/64", average wall thickness .090". That hollow flanged section was no cinch. But an ingenious metal-working schedule took care of that. Specifications were met 100% . . . and costs were surprisingly low.

Whether your electronic equipment requires small components or large assemblies, you, too, can save time, trouble and money by calling on Scovill's design ingenuity and versatility in all metals and all metal-working techniques. To learn why Scovill is in a position to give you impartial advice about whether to forge, draw, stamp or machine your Electronents*, send for literature. Fill in the coupon below and mail it today.

*Electronents = Electronic Components

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MANUFACTURING COMPANY
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Please send me a free copy of "Masters of Metal" booklet describing your facilities. I am interested in the ELECTRONENT* applications checked.

☐ Batteries	☐ Dials	☐ Panels
☐ Record Changers	☐ Escutcheons	☐ Sockets
☐ Clips	☐ Jacks	☐ Stampings (misc.)
☐ Condensers	☐ Lugs	☐ Tubes

Other applications .....

SCOVILL MANUFACTURING COMPANY
Electronic Division
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Name .....

Company .....

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No.
T-52
SPINTITE SET.
Chuck Type Handle with Reamawl, 3 Screw Drivers, 7 SPINTITES, Insulated Neutralizing Alignment Wrench, and 2 Pliers, all in a Leatherette Roll. . . .
A Positive need in every RADIO, HOME and ELECTRICAL SHOP.
A Fascinating, Fast-Moving Item for thousands of stores.
Your good jobber has it...

Send for Catalog No. 141 picturing a full line of Automobile, Aircraft and Radio Tools.

WALDEN WORCESTER WRENCHES

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468 SHREWSBURY STREET
WORCESTER, MASSACHUSETTS

tional Defense Research Committee, is made chairman of the Joint Board on Scientific Information Policy which will be responsible for the organization and release of scientific and allied information for OSRD, the War and Navy Departments, and the National Advisory Committee for Aeronautics.

DANIEL E. NOBLE has become general manager of the Communications and Electronics Division of

Galvin Mfg. Corp., Chicago, Ill. He retains his present responsibilities as director of research.

WILLIAM H. WILLS, former governor of Vermont, has been confirmed by the Senate as the seventh member of FCC.

CHARLES A. POWEL, president of AIEE and headquarters engineering manager for Westinghouse Electric Corp., becomes chief of the Electrical and Radio Branch of the Allied Control Commission in Germany, on leave of absence from Westinghouse.

W. G. H. FINCH, USNR, chief of the design branch, electronics division of the Navy's bureau of ships, goes from the rank of Commander to that of Captain.

AWARDS

Workers of the following concerns in the electronics field have been awarded Army-Navy "E" burgees for excellence in production:

Air King Products Co.
Brooklyn, N. Y.

Alliance Mfg. Co.
Alliance, Ohio

Garod Radio Corp.
Brooklyn, N. Y.

Presto Recording Corp.
New York, N. Y.

GOULD-MOODY
Improved
Professional Quality
"Black Seal"
ALUMINUM
INSTANTANEOUS
RECORDING BLANKS

Technological advancements brought about by our wartime assignments provide critical engineers with "Black Seal" blanks of improved cutting and reproduction qualities plus more satisfactory play-back life.

Rapid Deliveries to
Broadcasting Stations
Recording Studios
Motion Picture Sound Studios
Schools and Colleges
Governmental Agencies

Old Aluminum Blanks Recoated with "Black Seal" Formula on Short Notice

THE GOULD-MOODY COMPANY

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Cable Address: Recordisc, New York, N. Y.
Export Dept: Royal National Company, Inc.
89 Broad Street, New York

Electric Razors with Plaskon Housings

give clean, speedy shaves to servicemen

★ Recently, when Remington Electric Shavers went back into limited production, they were allocated for the exclusive use of hospitalized servicemen, and airmen whose faces are susceptible to frostbite.

The housings for these new Remington Electric Shavers are Plaskon Molded Color. This versatile plastic material lends many worthwhile advantages to the Remington Shaver.

Plaskon Materials can be molded into almost any desired shape, permitting unusual opportunity for handsome, practical designs in large quantities at very economical cost. They are available in a wide range of beautiful, permanent colors.

Plaskon Materials are strong and non-shattering, with a smooth, warm-to-the-touch surface that remains gleaming and sanitary. They are unaffected by oils or fats; alcohol, acetone, or any common organic solvents; and are odorless, tasteless and inert. They have high dielectric strength, and are completely resistant to arcing and tracking under high voltages and high frequencies.

Your products of today and tomorrow will enjoy profitable manufacturing and sales advantages if versatile Plaskon plastics can be adapted to their needs. Write for profusely illustrated booklet showing a great range of actual Plaskon applications to commercial and public needs. Experienced Plaskon men will gladly assist in adapting colorful Plaskon plastics to your individual requirements.

PLASKON

TRADE MARK REGISTERED

MOLDED COLOR

PLASKON DIVISION • LIBBEY • OWENS • FORD GLASS COMPANY • 2136 Sylvan Avenue • Toledo 6, Ohio

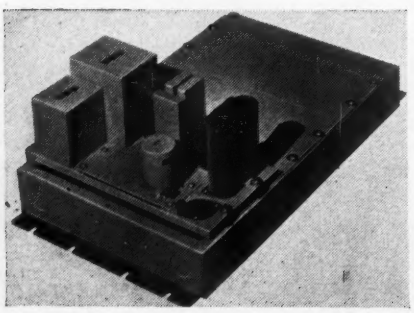
Canadian Agent: Canadian Industries, Ltd., Montreal, P. Q.

NEW PRODUCTS

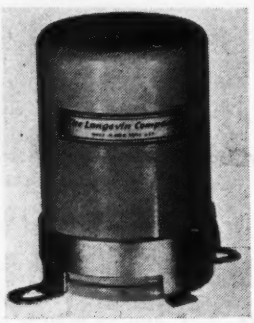
Month after month, manufacturers developed new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Langevin Products

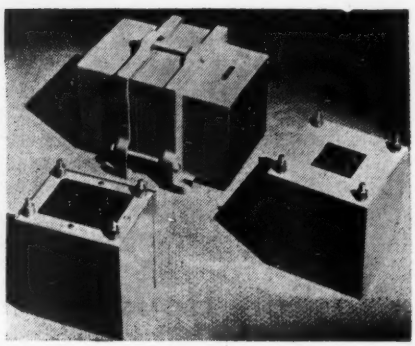
THE LANGEVIN Co., Inc., 37 West 65th St., New York, N. Y. announces three new products. The first is Type 3-A mounting frame for use in conjunction with their No. 102 Series amplifiers. The frame requires 10½ in. rack space



and will accommodate up to three of the amplifiers. It is suitable for wall mounting, rack or cabinet and panel installations. The second product is a new group of input transformers which are designated as the 400 Series. Three types are



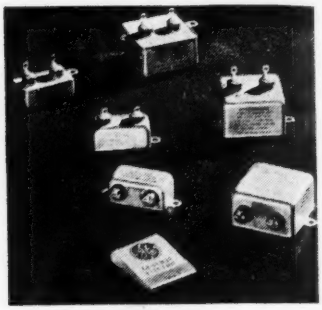
available. No. 401-A operates from 30/250/600 ohms primary to 30,000 ohms secondary, center tapped. Type 400-C bridging unit has a nominal impedance of 600/15,000 ohms to 60,000 ohms secondary. With proper input circuits, input impedance range is 0/25,000 ohms. The third type is No. 402-A with a nominal 30/120 ohms primary to 50,000 ohms secondary. Input impedance range is 0/250 ohms. Lastly, there are three new continuous-duty auto transformers with heavy lugs on their black bakelite terminal boards. Two types (800 and 801) are also available as hermetically-sealed units. Type 800-A —primary 220 volts, 60 cycles; secondary 110 volts, 250 watts; 5AS case; measures 4⅛ x 3⅛ x 5 in. Weight 10 lb. Type 801-A—primary 220 volts, 60 cycles; secondary 110 volts, 500 watts; 6AS case; measures 5⅛ x 4⅛ x 5 in. Weight



16 lb. Type 802-A—primary 220 volts, 60 cycles; secondary 110 volts, 1000 watts; housed in a No. 6 casting poured with humidity-proof compound; measures 9¼x7¼x6¾ in. weight 33 lb.

Capacitors

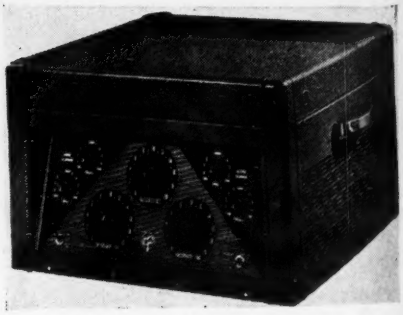
CASE STYLES CP-50, 51, and 52, characteristic F, are an addition to a complete line of fixed paper-dielectric capacitors recently announced by General Electric Co., Schenectady, N. Y. These capacitors meet government requirements for use in electronic communication and locating equipment for the Armed Forces. All three case styles are available in single-section (two bushings, case isolated), dual-section (two bushing, case grounded), and three-section designs (three



bushings, case grounded). Sizes range from 0.05 to 2.0 microfarads in ratings of 600 or 1000 volts. Weight varies from 2.3 to 5.8 oz. The primary difference in construction between the three case styles is the location of the bushings. Bulletin No. GEA-4357 is available.

Dual Amplifier

PLANT BROADCASTING or public address service is provided by the Soundcaster, a new 40-watt dual amplifier developed by Operadio Mfg. Co., St. Charles, Ill. Three models are available. Illustrated is



the basic Soundcaster (Model 1335) which provides quality control of high fidelity for all normal listening levels. Automatic changing mechanism or manually operated record turntable may be added to the amplifier.

Radio Filter

LOW-RESISTANCE type improved blower motor filters for radio transmitters or for loudspeaker applications are available in 10 x 2 in. or special sizes. Filters are made from expanded metal, are washable, per-

DeJUR

MODEL 120 . . . A New DeJUR Miniature Meter . . . precision instrument for more permanent accuracy in small panel space. Conforms to forthcoming JAN-1-6 specification . . . self-contained up to 1 ampere and 150 volts. D.C. or A.C. (rectifier) . . . external shunts or multipliers . . . in a wide variety of ranges.

ALNICO MAGNETS . . . highest grade . . . provide stability and quick response under high torque, with increased protection against magnetic fields.

EXTERNAL PIVOTS . . . insure maximum accuracy . . . reduce pointer-rocking, side friction between jewels and pivots, and wear on bearing surfaces.

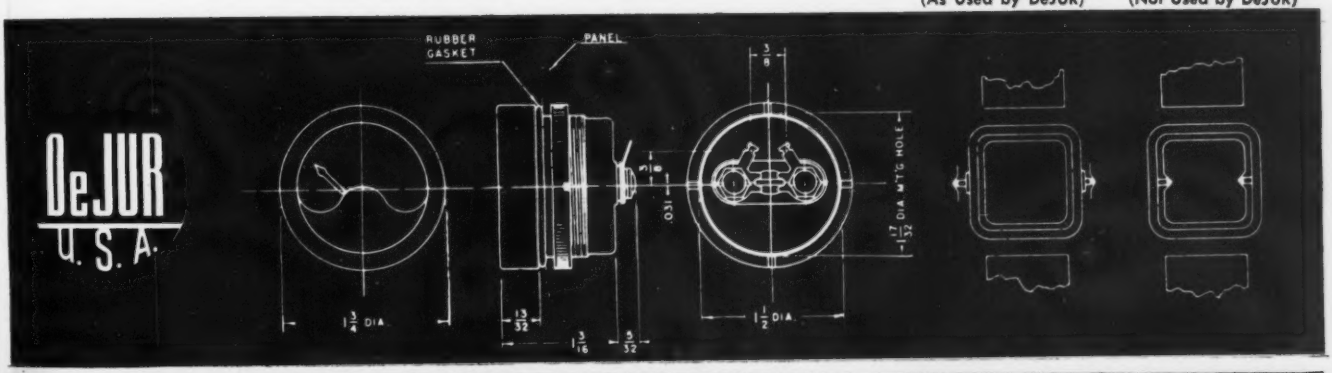
EXTRA-TIGHT SEALING . . . completely waterproof . . . in addition, rubber gasket seals flange to panel. Model 120 is particularly adapted for water-proof equipment.

For full information on DeJUR Miniatures and special applications, write

DeJUR-AMSCO CORPORATION, Long Island City 1, N.Y.

Compact, Trouble-Free Modern Design

External Pivot (As Used by DeJUR) **Internal Pivot** (Not Used by DeJUR)



Model 120 . . . Exploded View
Black Anodized Aluminum
Case . . . Ring-mounted
1 1/2 INCH
With the accuracy resulting from external pivot design.

AMMETERS . . . VOLTMETERS . . . POTENTIOMETERS

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Modern Electronic Inspection methods bring a new, high degree of speed, accuracy, and economy to this production operation. Today's inspection equipment is designed to keep pace with modern production methods. Its amazing efficiency is best employed when expert W-J inspection engineers make a study of *your* requirements and apply the equipment ideally suited to your needs. Let us show you the applications of X-Ray machines, diffraction units, spectrometers, electronic comparators, photoelectric units and electronic measuring equipment, to your particular problems! Fill in and mail the coupon *today!*

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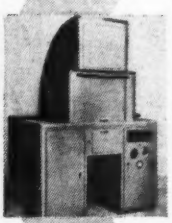
ECTRONIC COMPARATOR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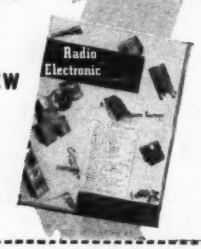

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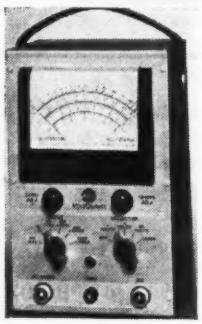
manent and effective in keeping dust particles out of radio apparatus. Badger Corp., Milwaukee 12, Wis.

Voltage Testing Device

IMPROVEMENTS featured in the new RCA 195-A Voltohmyst include a diode for a-c measurements, a linear a-c scale for all ranges, a new crystal-clear plastic meter case with



a one-piece unbreakable front, and shielded a-c cable and probe. The instrument combines in one unit the means for measuring d-c or a-c voltage, resistance, audio level, and f-m discriminator balance. RCA Victor Div. of Radio Corp. of America, Camden, N.J.

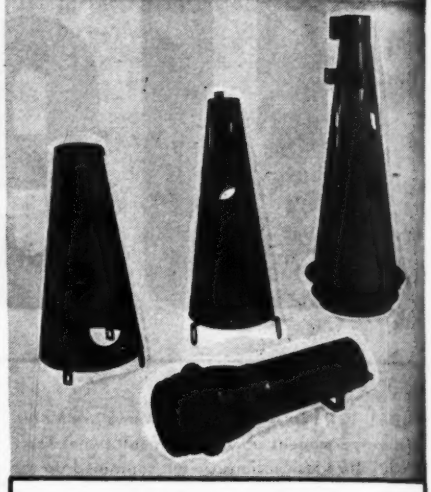
Non-Corrosive Flux

ORIGINALLY developed for the Armed Forces, Zenith non-corrosive Super Flux is now available to the industry for use in soldering electrical connections or as a soldering flux on copper, cadmium-plated brass and steel, and black steel. It can also be used to facilitate tinning of soldering tips. The flux is easily applied by brush or dipping and readily adheres to the work. Polan Industries, Huntington 19, W. Va.

Relay Connector

CANNON ELECTRIC Development Company (3209 Humboldt St., Los Angeles 31, Calif.) announce that their Type RR-1 and RR-2 railroad signal relay connectors are adaptable to all types and makes of relays in test requirements. The complete connector is made up of a plug and receptacle, having phenolic shells. Two guide posts assure correct polarization. These connectors are adaptable to 4 to 6-point relays.

• M A C O •



CATHODE RAY TUBE SHIELDS . . .

. . . to meet your specifications. These are only a few of our many available shields.

- **FABRICATED** from Mu-Metal or Nickelol
- **TESTED** by proven use to meet all requirements
- **DESIGNED** to fit your needs

★ ★ ★ ★ ★ ★

* * Our engineers will design in any metal — shields, chassis, cabinets, etc. for your individual application

★ ★ ★

METALLIC ARTS COMPANY

243 a Broadway

CAMBRIDGE, MASS.

For Quick Visual Indication

Investigate the Unique Characteristics of G-E Neon Glow Lamps

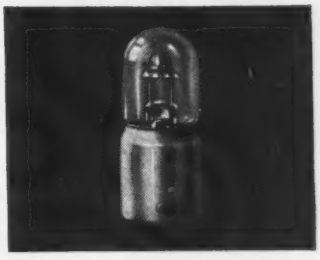
THE unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

CONSIDER THESE ADVANTAGES

1. Distinctive orange-red glow — no colored cover glass needed.
2. Dependable performance and long life — rated at 3,000 hours.
3. Very low current consumption — less than ½ milliampere for smallest lamp.
4. Variety of sizes and wattages.
5. High resistance to vibration, shock.
6. Normally usable on a-c or d-c.
7. Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.
8. Produce practically no heat.
9. Nearly flat volt-ampere characteristics.
10. Insensitive to voltage variations above critical value.

NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.



NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

NE-48 (also N-E 16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

*NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.

ORDER NO.	NE-2	NE-51	NE-17	NE-48	NE-16 ④	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/23	1/23	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC	65	65	③	65	—	65	60	60	60	60	60	60
Starting Voltage ① DC	90	90		90	⑤	90	85	85	85	85	85	85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Overall Length	③ 1 1/16"	1 3/16"	1½"	1½"	1½"	1 5/16"	2 1/16"	2"	3 1/16"	3¾"	3 5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

Specialists in Special Crystals

100 KC FREQUENCY STANDARD CRYSTAL

. . . Designed to withstand severe shock and vibration. A crystal so precisely finished that it has less than 15 cycles drift from -50C to +85C*. (If oscillator or circuit is furnished, an accuracy of 3-5 cycles can be obtained) . . A special solder bead supports a tensile load of 9,000 lbs. per square inch. Crystalab engineered to meet the most rigid operating requirements.

*Also available in frequencies from 80.86 to 200 KC.

Yankee Ingenuity makes us
SPECIALISTS IN SPECIAL CRYSTALS

Write Dept. E.L. for comprehensive catalogue "Selectronic Crystals" and facilities booklet "Crystalab Solves a Problem".

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New York Office 15 E. 26th Street, New York 10, N. Y. Phone M. H. 5-7952

Here's that New
TRIPLETT 625-N

Long Scale, Wide Range Volt-Ohm-Milliammeter

DIRECT READING OUTPUT LEVEL DECIBEL RANGES
−30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D.C. MILLIAMPERES
0-1-10-100-1000 Milliamperes, at 250 M.V.

D.C. AMPERES
0-10 Amperes, at 250 M.V.

OUTPUT READINGS
Condenser in series with A.C. Volts for output readings.

ATTRACTIVE COMPACT CASE
Size: 2½" x 5½". A readily portable, completely insulated, black, molded case, with strap handle. A suitable black, leather carrying case (No. 629) also available, with strap handle.

LONG 5" SCALE ARC
For greater reading accuracy on the Triplett RED •DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

DOUBLE SENSITIVITY D.C. VOLT RANGES
0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A.C. VOLT RANGES
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM—MEGOHMS
0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)

Write for descriptive folder giving full technical details.

Triplett ELECTRICAL INSTRUMENT CO., Bluffton, Ohio

Reproducer for Railroad Use

TYPE NJ-300 REPRODUCER was originally designed for Navy Use as a loudspeaker and microphone (talk-back) unit but it is now available for all types of railroad use in locomotives, cabooses, signal towers, and out-doors in railroad yards. The reproducer consists of Type NF-300 speaker (described in July issue) enclosed in a special rail-

road-type cast aluminum case. The unit can be mounted in any position. It is rugged and is capable of withstanding shock and vibration, as well as prolonged exposure to smoke, dust and other elements. Voice coil impedance is rated at 12 ohms nominal value. Power handling capacity for speech is rated 10 W. Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 39, Ill.

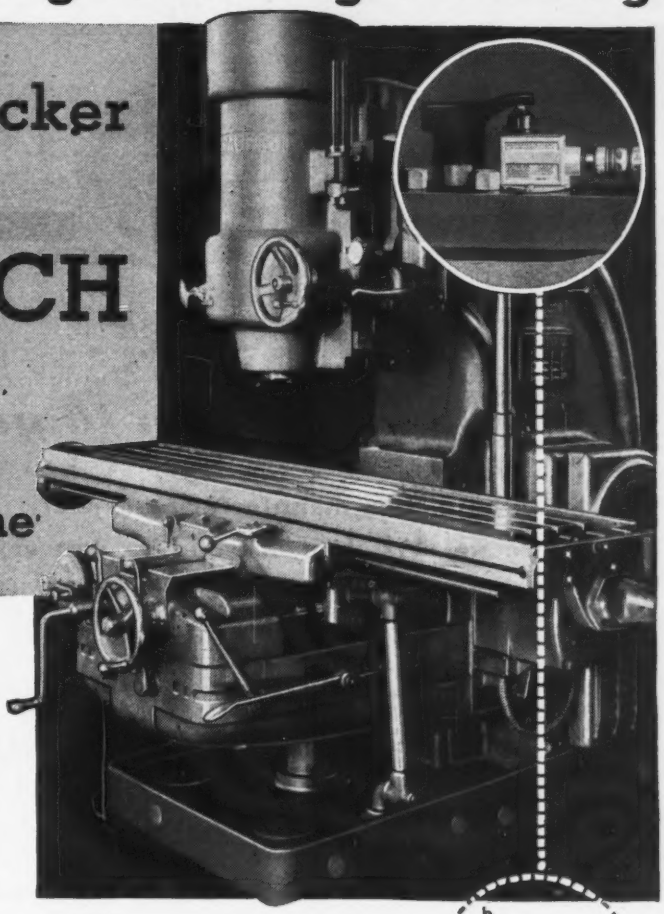
High-Temperature Capacitors

PLASTICON, Type AS, silicone impregnated, plastic film, dielectric capacitors are capable of continuous operation at 256 F. These units are light and compact, and can be used at maximum temperature at full voltage rating. They are made

only to specification in all capacitances and voltage ratings in all varieties of standard and special cans, and in the Glassmike construction. An 0.01 μf, 5000 working volts, Plasticon Type ASG measures 1¾ in. long x ¾ in. O.D. Condenser Products Co., 1375 N. Branch St., Chicago 22, Ill.

A Positive Angle on Negative Angle Milling

How Kearney & Trecker Use MICRO SWITCH SNAP-ACTION As Inching Switch on Milwaukee Milling Machine



WHEN Kearney & Trecker designed this big new 50 HP. C.S.M. Milwaukee Milling Machine, especially for negative angle milling, it was important that the inching switch, used for synchronizing gears, be rugged and dependable. A Micro Switch sealed plunger switch with a die cast housing was installed so that it is operated by an actuator head controlled by the inching button.

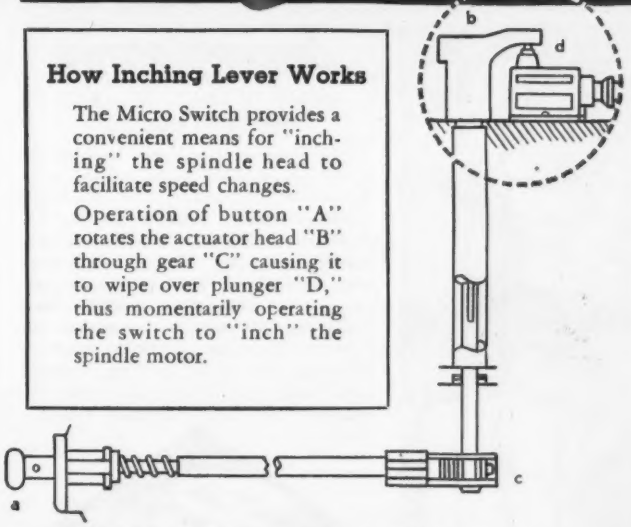
This switch was selected because it combined the precision, capacity, and durability required by the milling machine manufacturer. Micro Switch snap-action can be counted on for millions of operations, all equally accurate. There are over 2700 different combinations of switches, contacts, actuators, and enclosures.

Send for the Handbook-Catalog No. 60 shown at right—it gives specific, helpful information on Micro Switch products.

How Inching Lever Works

The Micro Switch provides a convenient means for "inching" the spindle head to facilitate speed changes.

Operation of button "A" rotates the actuator head "B" through gear "C" causing it to wipe over plunger "D," thus momentarily operating the switch to "inch" the spindle motor.



Send for this free Handbook-Catalog

Gives complete details as to electrical characteristics, construction, dimensions, operations, and applications. If you are specializing in aircraft equipment, ask for Handbook-Catalog No. 71, also.

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MICRO MS MARK TRADE SWITCH

A DIVISION OF FIRST INDUSTRIAL CORPORATION

Freeport, Illinois, U. S. A., Sales Offices in Principal Cities

Buy More War Bonds

To Finish the Job!

The basic switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a. c. Capacity on d. c. depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

For more than 10 years

we have been manufacturing crystals. Not only are we crystal manufacturers, but crystal specialists as well. Consult us on your "crystal problems".

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PETERSEN RADIO CO.

Council Bluffs, Iowa

CRYSTALS EXCLUSIVELY SINCE 1934

Increased service-

result of tough precision-fabricated materials

Exceptional electrical and mechanical properties of fibre parts, when fabricated with accuracy and precision, greatly expand product service-life. Vulcanized fibre with resistance to oils, fumes, corrosion, impact and vibration, and phenol fibre with resistance to moisture absorption, represent two materials particularly adaptable to many applications. BAER facilities for stamping, punching, drilling, milling, machining, and sawing completes the solution for close tolerance fabrications.

Baer

PHENOL AND VULCANIZED

FIBRE

FABRICATIONS

FOR INDUSTRY

LITERATURE ON REQUEST. The BAER fibre fabrication data bulletin—crammed with pertinent information and specifications relating to both phenol and vulcanized fibre—will be sent promptly on request on company letterhead. Write for Bulletin ,120.

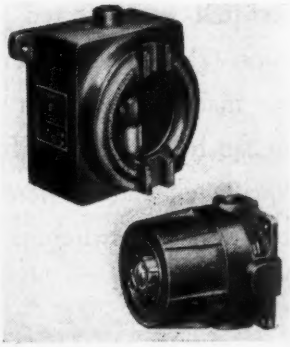
N. S. BAER COMPANY, 9-11 MONTGOMERY ST., HILLSIDE, N. J.

Regulated Power Supplies

A NEW SERIES of saturable-reactor regulated power supplies has been developed by Amplifier Co. of America (398 Broadway, New York 13, N. Y.) for applications requiring d-c voltages regulated to better than 5 percent from full load to no load, and having less than 1 percent ripple under full load. These units may be used as storage battery substitutes or to replace d-c generators. Standard power packs available in this new series are rated 24-v, ½ amp or 2 amp; 48 v, 1¾ amp or 5 amp; a combination 24 and 48 v, 750 ma; 36 v, 1 amp; 110 v, 8 amp; 120 v, 200 ma; 135 v, ½ amp; 250 v, 4 amp; 500 v, 200 ma. These power packs may be furnished with built-in automatic voltage regulators to compensate for line voltage changes.

Smoke Detector

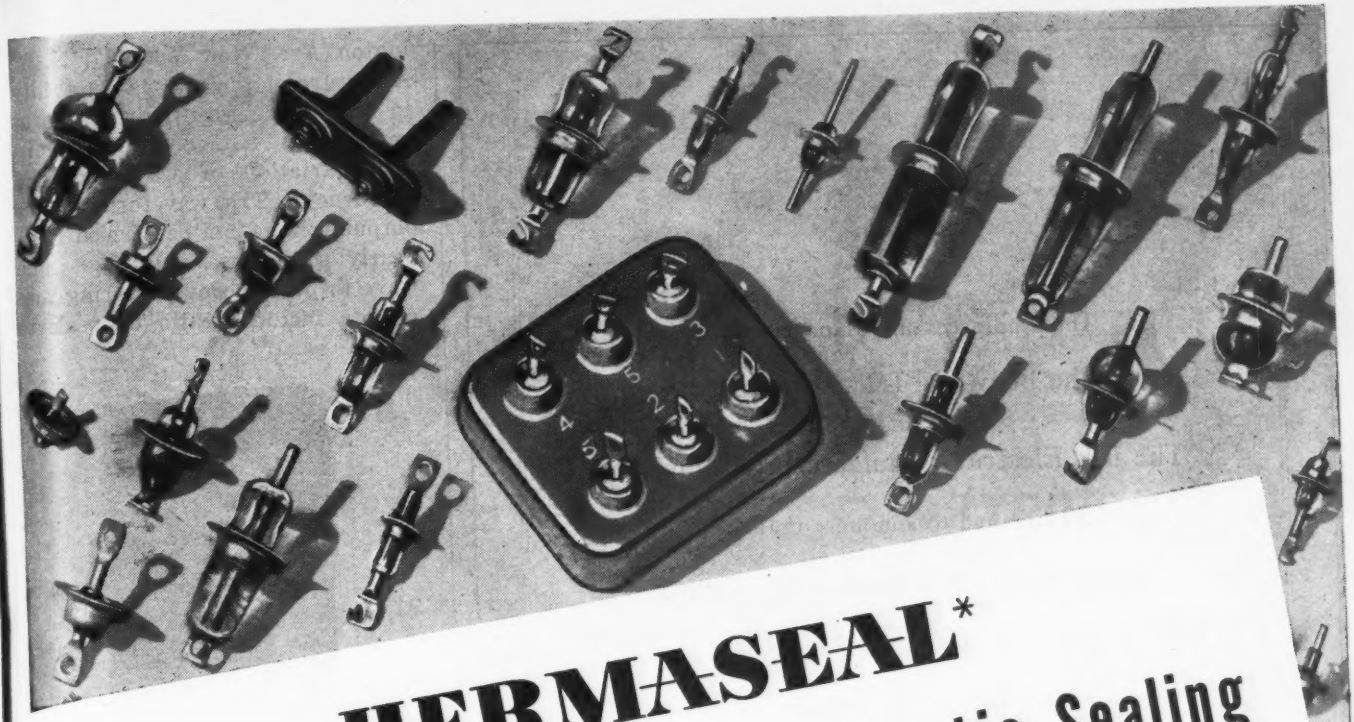
A PHOTOELECTRIC control system which detects smoke in air conditioning ducts is announced by Photoswitch Inc., 77 Broadway, Cambridge 42, Mass. The system consists of photoelectric control Type A26X and light source Type



L11RX. The latter may be mounted to project a beam of light over any distance from 10 to 25 ft. The intensity of the light beam may be set so that the control will respond to smoke of a predetermined density.

Electronic Generator

MODEL NO. RL-1 IS a variable waveform, variable frequency electronic generator manufactured by Radio-Television Institute, Inc., 480 Lex-



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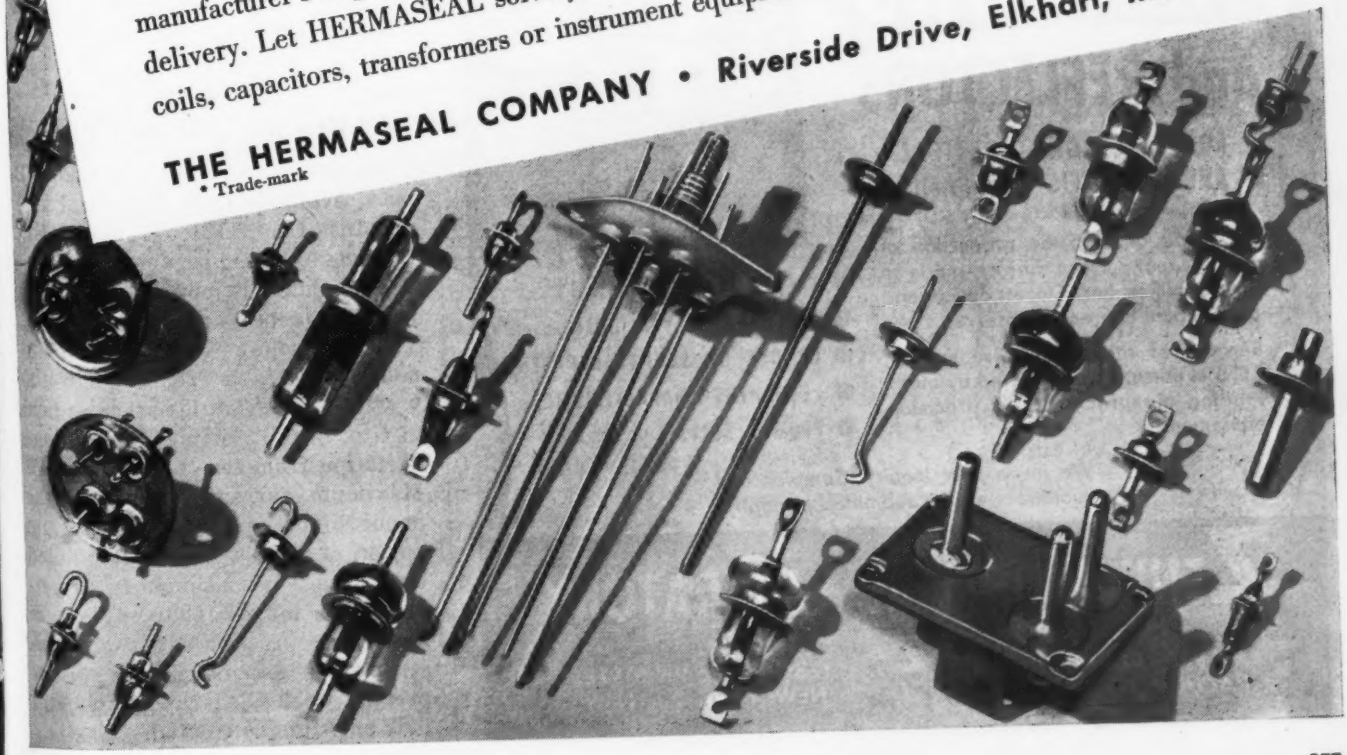
For TRUE and PERMANENT Hermetic Sealing

Literally hundreds of different types of glass and metal seals have been engineered by HERMASEAL to meet today's exacting demands for military electronic equipment. • HERMASEAL engineers have been actively engaged in the solution of glass and metal seal problems for the last 17 years and have pioneered many of today's accepted standards in hermetically sealed enclosures. • We specialize in building seals to meet the manufacturer's requirements; however, accepted standard seals are available for immediate delivery. Let HERMASEAL solve your problem of hermetic sealing whether it be relays, coils, capacitors, transformers or instrument equipment. For fast action *write, wire* or *call*

THE HERMASEAL COMPANY • Riverside Drive, Elkhart, Indiana

* Trade-mark



The Employees and Management of

The Benwood-Linze Company

and

The B-L Electric Manufacturing Company

are honored to announce that the

Army-Navy "E" Production Award

for Excellence in War Production

was made to the company on

Thursday, August twenty-third

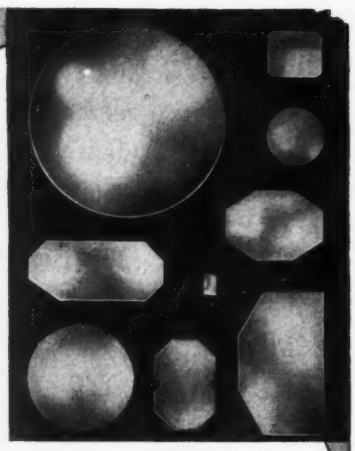
Nineteen hundred and forty-five

OPTICAL

MIRRORS

and REFLECTORS

FOR ELECTRONIC, OPTICAL AND SCIENTIFIC APPARATUS



WE specialize in the production of front or rear surface mirrors, made to your specifications. Closest optical and dimensional tolerances observed.

Because of their proven superiority, ZENITH mirrors are preferred by many leading manufacturers of precision equipment.

- EXCEPTIONAL REFLECTIVITY
- ALUMINUM, SILVER, GOLD, etc.
- OPAQUE OR SEMI-TRANSPARENT
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- PROMPT SERVICE

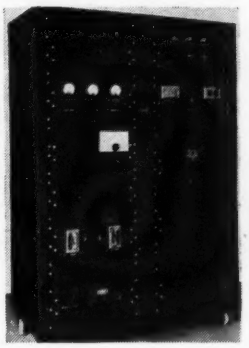
We invite your inquiry. Samples and quotations will be submitted promptly.

ZENITH OPTICAL LABORATORY

SPECIALISTS IN VACUUM DEPOSITION

123 WEST 64th STREET
NEW YORK 23, N. Y.

ington Ave., New York 17, N. Y. A feature of the unit is its ability to maintain essentially constant rms output voltage while permitting variation of waveform and frequency. The waveform of the output voltage can be carried from nearly square wave through sine wave to peaked wave covering amplitude factors (ratio of peak to



rms volts) of from 1.16 to 1.65. The frequency is variable over a range from 50 to 2400 cps. Output voltage is 115 v rms nominally, adjustable between 110 and 120 v. Regulation of output voltage is better than 3 percent from no load to 300 w, and for line voltage changes from 110 to 120 v a-c. The output voltage stays within the same limits for frequency changes over the whole range, as well as for changes in amplitude factor from 1.16 to 1.65. Units can be designed for other output voltage and power ratings and frequency ranges.

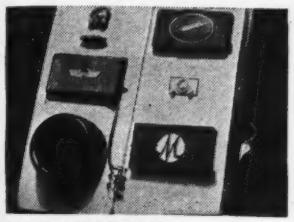
Self-Regulated Power Pack

THE NEW TAC MODEL 1220-EB pack, available from Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass., provides two voltage-regulated d-c outputs on ranges used for anode and bias voltages. The high-voltage output is continuously adjustable from zero to 400 v with voltage automatically held at its initial setting under load variation from zero to full current. Maximum current output on the anode supply is 250 ma; maximum power output is 40 w. Regulated bias voltage is continuously adjustable from minus 100 v to zero at maximum current of 2 ma. The instrument is assembled with oil-impregnated oil-filled capacitors, and it is anti-fungus treated.

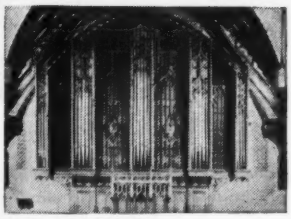
B-L METALLIC RECTIFIERS

SELENIUM COPPER SULPHIDE

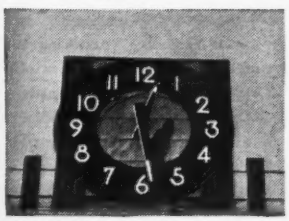
A few B-L Rectifier applications are illustrated below:



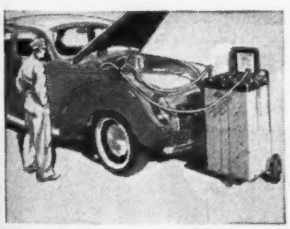
AUTO RADIOS



PIPE ORGANS

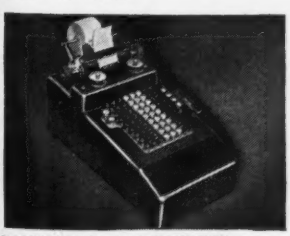


CLOCKS



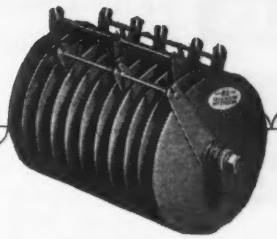
BATTERY CHARGERS

FIRE TRUCKS



BUSINESS MACHINES

from AC →



→ to DC

B-L METALLIC ELECTRICAL RECTIFIERS (SELENIUM COPPER SULPHIDE)

offer you these advantages:

***They are* COMPACT**

For a given power output the space required by metallic rectifiers is very small.

***They are* SILENT**

B-L Rectifiers are silent in operation and have no moving parts.

***They are* DEPENDABLE**

Dependability is assured by their simple and rugged construction, in which no glass bulbs, filaments, or other fragile parts are employed.

***They are* TROUBLE-FREE**

Regular maintenance and attention are unnecessary.

***They are* RUGGED**

B-L Rectifiers are rugged and will withstand heavy overloads for short periods of time.

***They are* ADAPTABLE**

B-L Rectifiers are adaptable for power outputs from Milliwatts to Kilowatts.

Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC... Write for Copper-Sulphide Bulletin R38-A — or for Selenium Bulletin R41-A.

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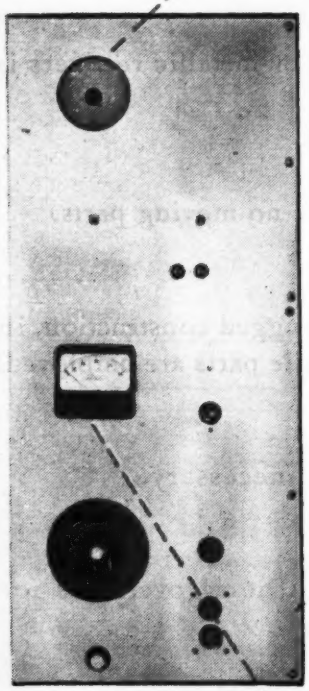

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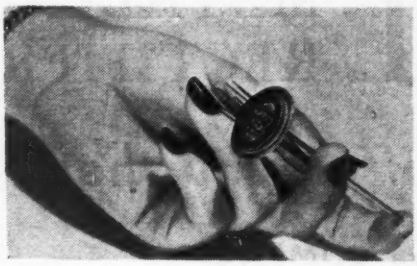
Airtight Steel-To-Glass Seal

A NEW METHOD of fusing steel and glass in a permanent airtight seal for metal electron tubes has been revealed by Dr. G. R. Shaw, Chief Engineer of the Tube Division of the Radio Corporation of America, Harrison, N. J. The method provides a more foolproof process, and



permits the use of steel for the glass-to-metal seal in place of special alloys. Steel was used for the header insert (the ring-like band of metal encircling the glass button through which the wire leads are introduced into the tube) shown in the illustration.

Handie-Talkie Production

PORTABLE handie-talkie sets are being made for civilian use for farms, ship-to-shore communication with small boats, manufacturing operations, etc. by John Meck Industries, Inc., Plymouth, Ind. FCC has assigned a band of 460-470 mc for handie- and walkie-talkie use by civilians.

Electrical Insulation

THE VARFLEX CORP., Rome, N. Y., has developed and is now producing a new type of electrical insulation based on the silicone high-temperature resins in combination with normalized Fiberglas. It is made in various grades of tubing,

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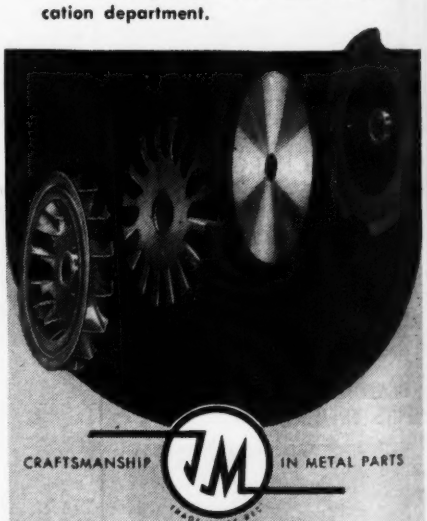

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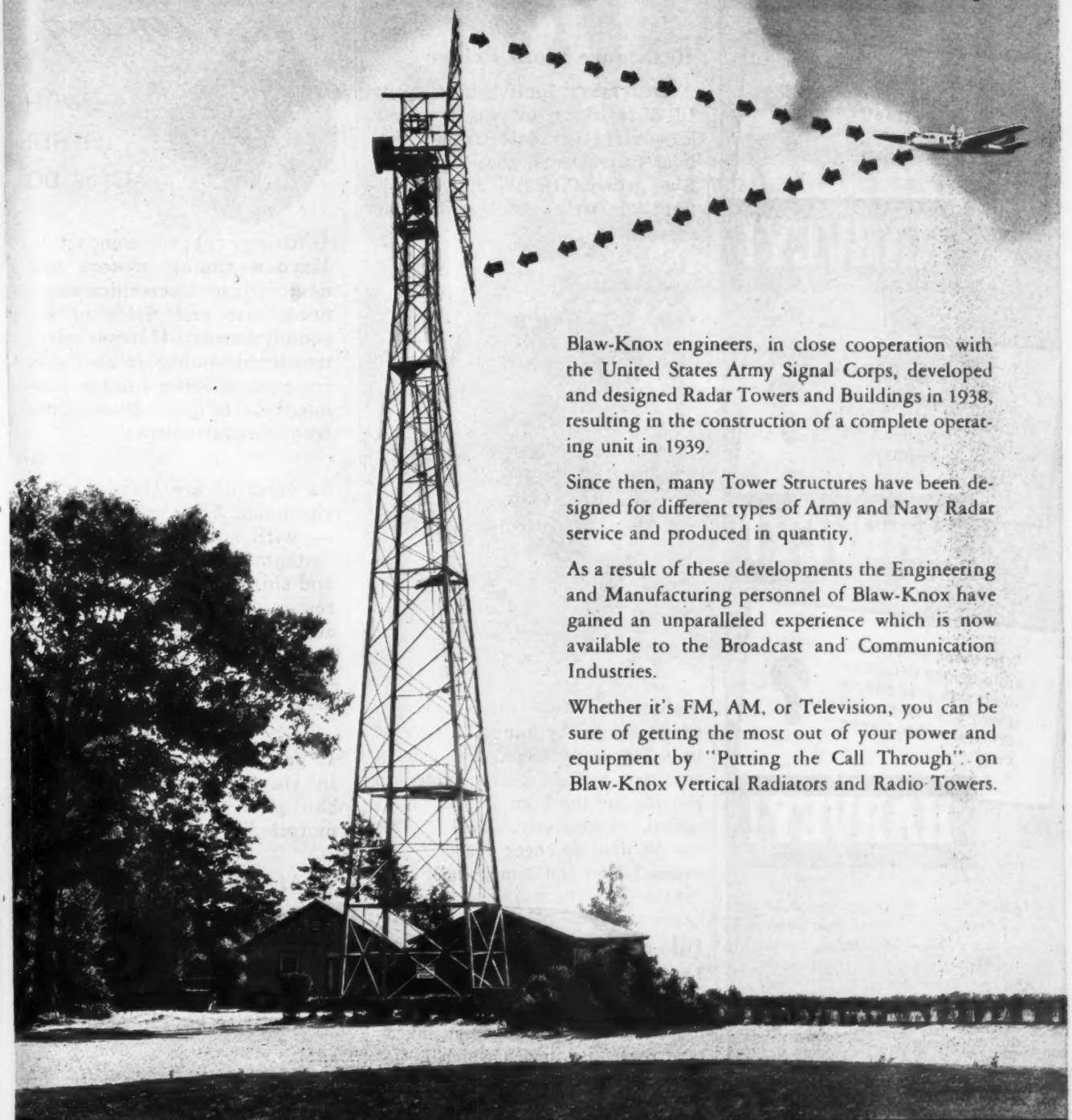

Blaw-Knox engineers, in close cooperation with the United States Army Signal Corps, developed and designed Radar Towers and Buildings in 1938, resulting in the construction of a complete operating unit in 1939.

Since then, many Tower Structures have been designed for different types of Army and Navy Radar service and produced in quantity.

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sleeving, and tying cord, and can be furnished on some types of wire and cable. Silflex sleeving can be tied in knots and chafed at −85 F. It remains flexible and physically stable at + 450 F indefinitely. Literature and a sample card showing the various types of insulation available will be sent by Varflex Corp.

Resistance Limit Bridge

A RESISTANCE limit bridge, Model LB-3 (working to plus or minus 0.1 percent) available from Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J., is a modified Wheatstone bridge that has

high and low limit dials covering a range of plus or minus 11 percent in 0.1 percent steps, and uses a sensitive built-in galvanometer to provide for the high and low indication, respectively. This bridge can be used to check resistors between 1 ohm and 3 megohms.

Inked-Tape Recording Device

MECANITRON Corporation of Boston, Mass., has developed an inked-tape recording device which is designed for continuous high-speed reception and which is capable of receiving 1200 words per minute. This device is designated as Mecanitron Model MA-126. This unit comprises two complete recorder heads and pulse amplifiers. Inputs of the amplifiers are connected in parallel and are energized simul-

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Haydon

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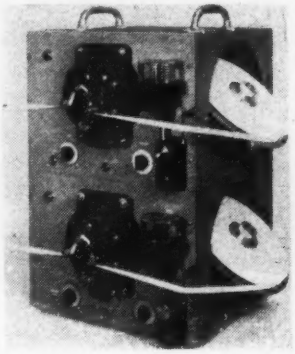
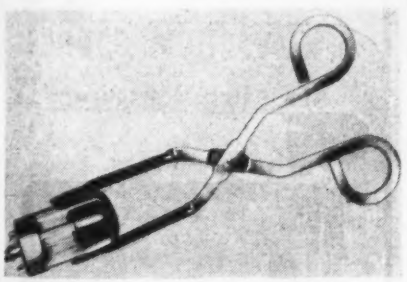
taneously from the same source. A stand-by switch is provided on each unit so that either recorder will function instantly on the same information. This allows the second recorder to carry on without interrupting the flow of high-speed material during the interval re-



quired to provide a new roll of tape for the first recorder. The Model MA-126 can also be furnished for relay rackmounting. It operates on either 110-220 volts, 60 cycles, or 220-230 volts, 25-50-60 cycles. Designed for efficiency at a rate of 1200 words per minute, the unit handles low and average speeds with ease.

Tube Extractors

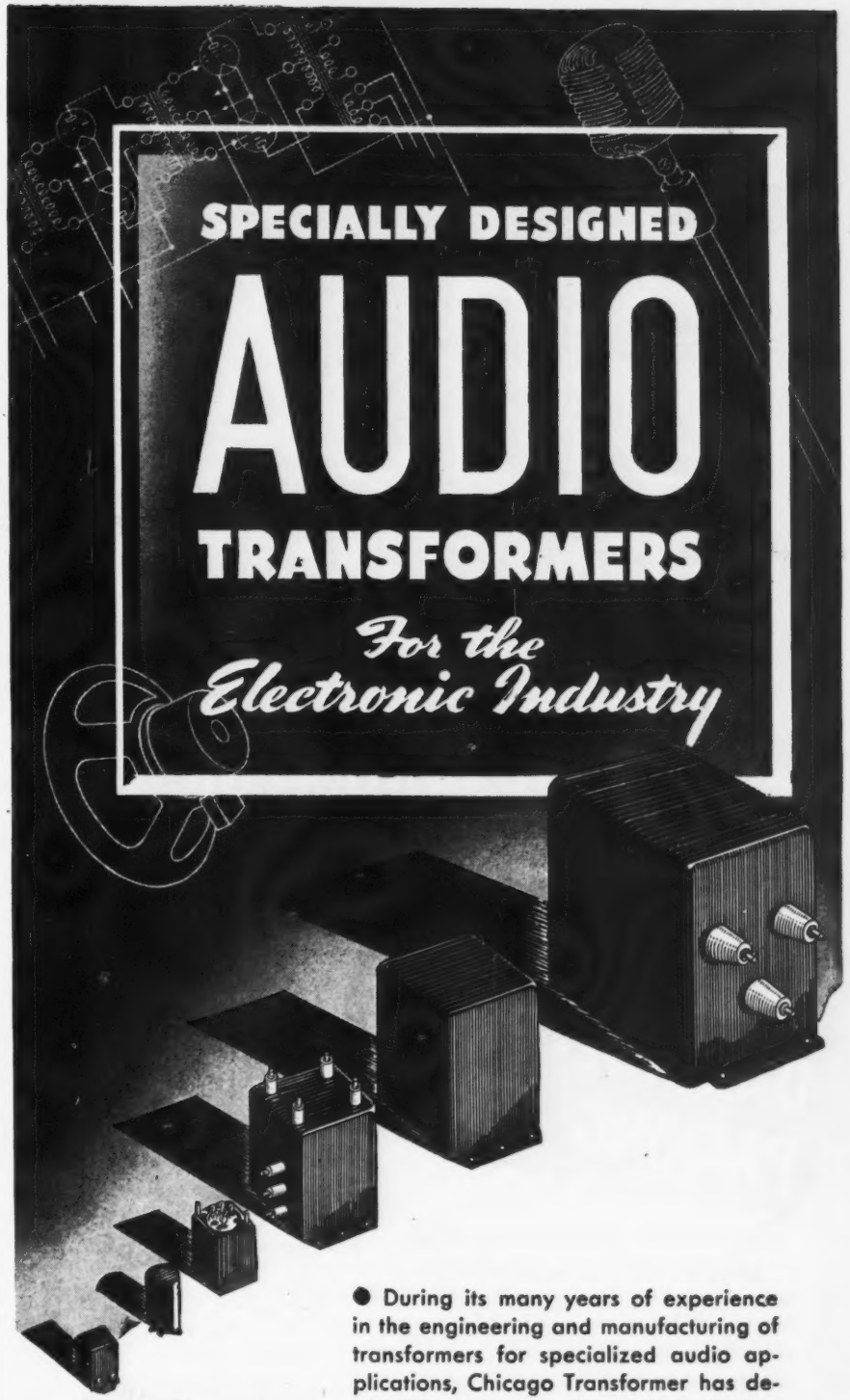
THE BMG COMPANY of Boonton, N. J. announces a new addition to its "Sure-Grip" tube extractors used in the inserting and extracting



of delicate miniature and straight-side glass radio receiving tubes manufactured in standard bulb sizes T5½, T7, T8 and T9.

Low-Voltage Rectifiers

ILLUSTRATED IS a stabilized low-voltage rectifier manufactured by Green Electric Co., 130 Cedar St., New York, N. Y. It is rated at 200 amp, voltage range zero to 3 v. Any voltage selected in the range is maintained to within 50 millivolts



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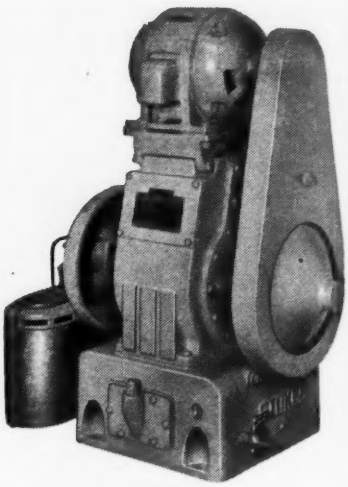

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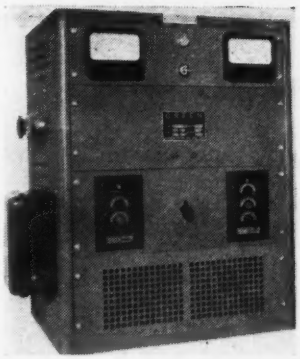
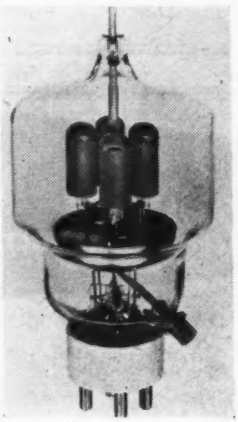


over load variation from zero to 200 amp, and with line voltage variation of plus or minus 10 percent. The unit's voltage stabilization system includes a motor-driven Powerstat and a simple electronic pilot device.

Triode Tube

ILLUSTRATED is a new type 304TL (3-300B2) multi-element triode which incorporates a new design plate and a non-emitting grid to assure maximum tube life and high efficiency. The tube has many ap-



plications including television and industrial heating. Data sheets are available from the manufacturer, Eitel-McCullough, Inc., 478 San Mateo Ave., San Bruno, Calif.

Non-Linear Potentiometer

THE FAIRCHILD Camera and Instrument Corporation (475 Tenth Ave., New York 18, N. Y.) announce a non-linear wire-wound potentiometer which has a high degree of operating accuracy. The manufacturer states that tolerances of one-half percent or better have been consistently reached for certain curves. Developed originally for use in bridged T attenu-

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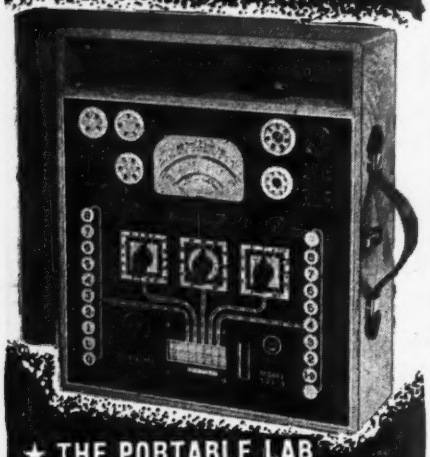

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AC VOLTS: 0-5-10-50-250-1000
OUTPUT VOLTS: 0-5-10-50-250-1000
OHMMETER: 0-200-2000-20,000 OHMS 0-2-20 MEGOHMS
BATTERY TEST: Check Dry Portable "A" and "B" Batteries Under Load
CONDENSER CHECK: Electrolytics checked on English Reading Scale at Rated voltages of 25-50-100-200-250-300-450 volts.
TUBE TESTER: Emission type with noise test floating filaments, easy chart operation. Checks all receiving type tubes.
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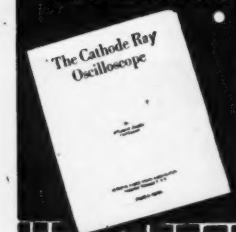

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ators in Fairchild's airborne electronic computing gunsights, the potentiometer is at present available to industry in one standard size (1¾-in. outside diameter). It can be used singly, or stacked. Other features of the unit include good flexibility for reproducing any desired curve within certain limits, small size, long life with sustained accuracy, and the ability to replace more costly alternative circuits and components.

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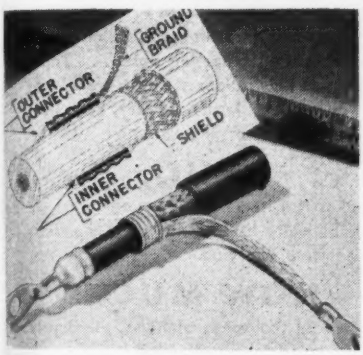
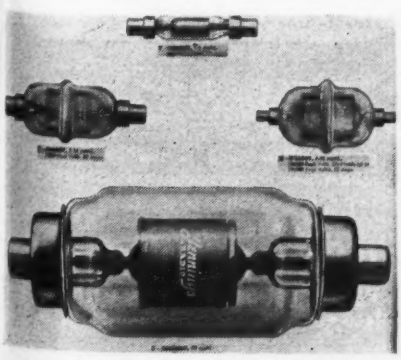
DESIGNED especially to simplify the making of connections, taps, and splices in coaxial and shielded cable are connectors announced by Burndy Engineering Company (17



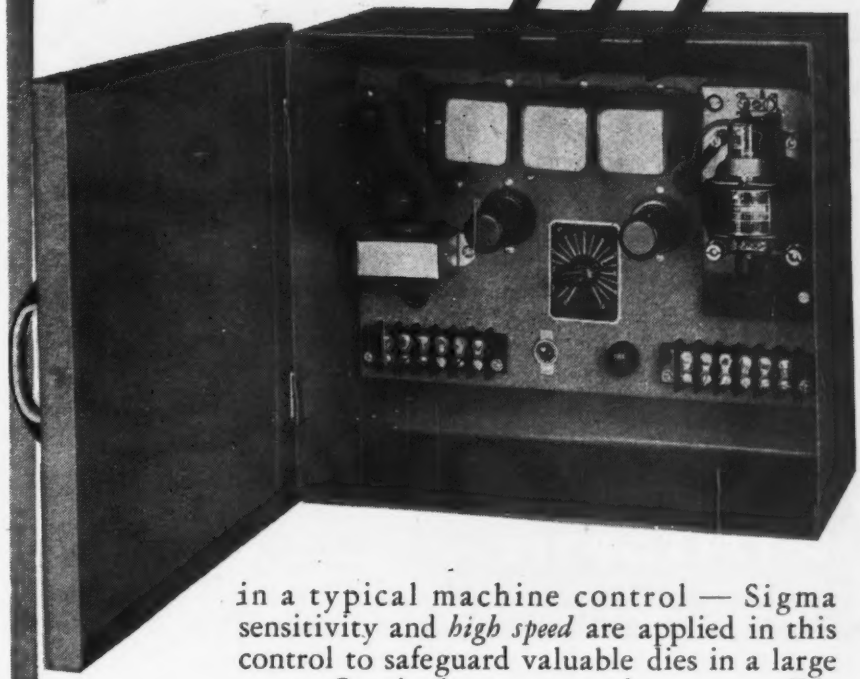
Bruckner Blvd., New York 54, N. Y.) as an addition to their line of Hydant products. The connectors aid in the elimination of soldering and minimize the possibility of insulation being damaged by heat.

High-Vacuum Capacitors

JENNINGS RADIO Mfg. Co., 1098 E. William St., San Jose, Calif., announces four new high-vacuum capacitors ranging from 1 $\mu\mu$f at 7½ amp, 3,000 peak volts to 250 $\mu\mu$f at 60 amp, 20,000 peak volts and a special high-power unit rated 50,000 peak volts. Capacitors are



here are 3 SIGMA RELAYS



in a typical machine control — Sigma sensitivity and *high speed* are applied in this control to safeguard valuable dies in a large press. Continuing press cycles are possible only as each formed piece is ejected and monitoned by the control.

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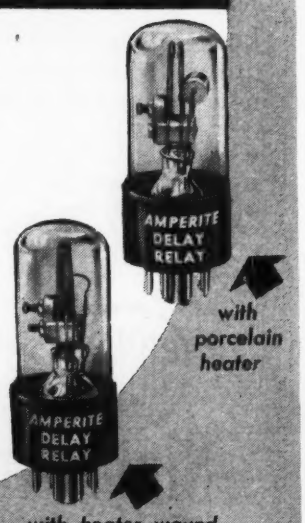

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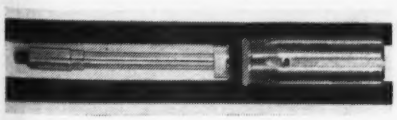
Torque Tool

SPEED AND COMFORT in operation are features of a spintite-style tool designated as "Tork-Tite" which makes possible torque tightening in inch-ounce settings in precision instruments. The torque-limiting action of the tool eliminates possibility of over-tightening and assures accuracy where sensitive and definite torque accuracy is required



for assembly or laboratory work. The tool is available in two models, with either fixed or adjustable torque setting. The adjustable model is quickly set to a desired torque reading in the handle. Skyway Precision Tool Co., 3217 Casitas Ave., Los Angeles 26, Calif.

Screen Booth Filter

A NEW POWER-LINE filter for use with screen-rooms prevents entrance of objectionable line noise at all frequencies from 150 kc to 400

Burlington

PANEL INSTRUMENTS

Guaranteed ACCURACY

Due to design characteristics and close control of manufacturing processes, Burlington instruments embody the following advantages:

PERMANENCE OF CALIBRATION . . . All DC instruments employ Alnico magnets which are known to be more highly resistant to shock, heat, vibration, and stray fields than any other magnetic material.

FREEDOM FROM STICKING . . . Clearances for all moving parts are such that the results of entrance of small particles as encountered in field service are reduced to a minimum.

STABILITY OF OPERATION . . . All instruments are "NORMALIZED" after assembly to eliminate "zero shift" and other calibration errors due to ageing.

Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

Alignment of jewels and magnet core piece is such that the center lines of these parts coincide within plus or minus .002". The design of the brass movement frame and components is such that mechanical tolerances are reduced to a minimum in assembly. As a result, jewel and pivot wear is uniform which reduces "frictional torque" of the moving coil.

All series resistors and coils are heat treated and impregnated after wrapping to insure stability and long life.

All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

Engineering service furnished for specialized applications. No obligation. Write today for further information.

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100 FOURTH STREET
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PANEL INSTRUMENTS • VOLTAGE REGULATORS • AUTOMATIC SYNCHRONIZERS • FREQUENCY REGULATORS

ARMY E NAVY

POWER Rheostats

★ Insulated metal core supports resistance winding. Winding imbedded in "Greenohm" cold-setting inorganic cement.

★ Normal current rating may be exceeded by 50% at any setting up to 1/3 total rotation, without damage.

★ Rotor design provides smoothest rotation and positive conduction at all settings.

★ 1 to 5000 ohms in 25 watt; ½ to 10,000 ohms for 50-watt.

★ Detent action, hop-offs, special shafts, different terminals, etc. available on special order.

★ Hundreds of thousands of these Clarostat power rheostats are now in daily use. They are standard equipment in radio, electronic, aircraft and other wartime assemblies. Likewise in more and still more industrial equipment. They are proving that they "can take it"—and then some. No tougher controls are made.

The 25- and 50-watt units here shown are of the enclosed or protected type. Uncased units are also available, where the casing is not required. Wide choice of resistance values.

★ *Write for details . . .*

CLAROSTAT

Controls and Resistors

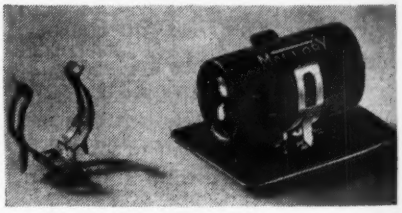
CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

mc. The unit is designed for continuous operation at 500 v d-c or a-c at a full-load current of 100 amp.

It is available for installation in two-wire and three-wire circuits, and provides attenuation better than 60 db over the entire band. Three-wire filters measure 23 × 12 × 4⅛ in. The two-wire filter measures 20 × 8 × 4⅛ in. Tobe Deutschmann Corp., Filterette Div., Canton, Mass.

Capacitor Mounting Clip

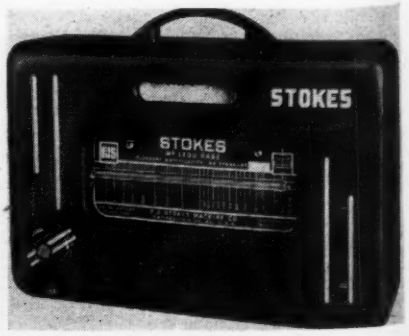
A NEW CAPACITOR-mounting clip that requires no tools for assembly is announced by P. R. Mallory & Co., Inc., Indianapolis, Ind. This clip, originated by Mallory and

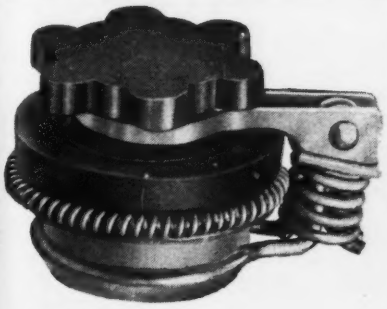


made by Prestole Division of the Detroit Harvester Co., Toledo, Ohio, is available in five sizes ranging from ⅝ to 1⅜ in. and is designated as Mallory Type TH or Prestol Series 500.

High-Vacuum Gage

REDESIGNED McLeod type portable high-vacuum gage with built-in





Waterproof Jack Covers

enable jacks to be completely sealed against water and moisture. No special holes or tools required.

Specified on many Navy items. Knob available in black or red. All necessary hardware included. Moderately priced.

Send for catalog on this and other waterproofing items.

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VACUUM TUBE VOLTMETER

RF — AC — DC

The result of 10 years of Vacuum Tube Voltmeter Engineering.

MODEL VM-27

1-3-10-30-100 volts full scale. Peak response, r.m.s. calibration.

HIGH IMPEDANCE—4 megohms at 50 cycles, 60,000 ohms at 100 megacycles. 7 megohms for d-c.

ACCURATE—Better than 2 percent on d-c and 60 cycles thru 50 megacycles.

SELF-CONTAINED—115 or 230 volt 50-60 cycle line operation.

RF PROBE

Interchangeable probe included for convenience and efficiency in making AC and RF measurements. Input capacity 5 micro farads. Ruggedly mounted 6H6 tube in balanced circuit. Complete voltmeter with probe $150 net f.o.b. Flushing, N. Y.

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To increase VM-27 range to 1000 volts.

10X AC MULTIPLIER MODEL ACM-27

Input impedance even greater than probe alone. Flat response from 20 cycles to 200 megacycles. $17.00 net f.o.b. Flushing, N. Y.

10X DC MULTIPLIER MODEL DCM-27

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ALFRED W. BARBER LABORATORIES
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Men with substantial experience wanted, preferably those having Degrees in Electrical or Communications Engineering. Write, giving details of experience and salary expected, to:

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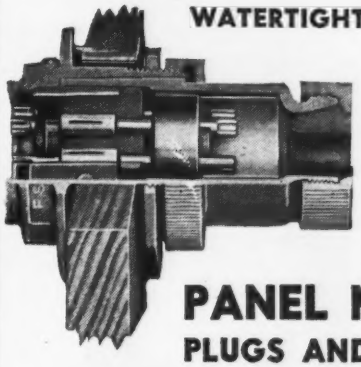

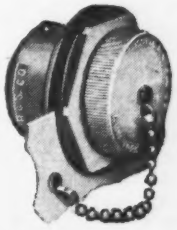

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For locknut or bolted style mounting to panels 1/16" to 5/8" thick. Precision built housings — light weight, ample wiring space.

Contacts fully machined, self wiping and free floating. All terminals identifed. Polarized, grounded and shielded.

Interior moulded bakelite. Moulded rubber gaskets on watertight style.

Thousands in use for vital war service.

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FOR PORTABLE SOUND AND SIGNAL SYSTEMS 2 to 12 POLE

FOR POWER 10 to 200 AMP. 2, 3 & 4 POLE

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FUNCTIONAL DEPENDABILITY

To meet the demand for precision-functioning resistors, impervious to moisture, heat and other detrimental conditions, IN-RES-CO types RB and SB were developed. Non-inductive, and with standard tolerance of ½%, type RB has a maximum resistance of 500,000 ohms, and measures 9/16" high and 9/16" in diameter. It is rated at ½ watt. Type SB is rated at 1 watt, has a maximum resistance of 1 megohm, and is 1 1/16" high and 9/16" in diameter.

Displaying excellent stability under adverse climatic and operating conditions, an additional feature of IN-RES-CO wirewound resistors is their low distributed capacity. The new IN-RES-CO catalog covering the complete line of dependable resistors, meter shunts and multipliers is available. A note on your company letterhead will bring it promptly.

INSTRUMENT RESISTORS CO.

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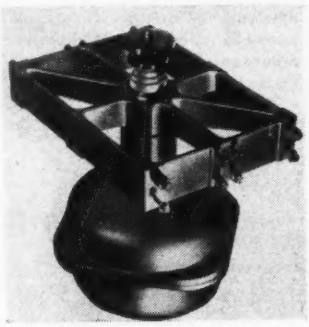
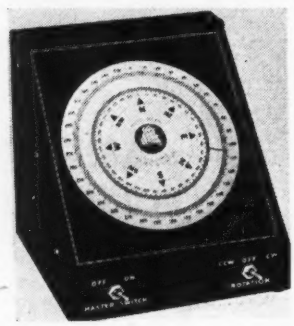
condensable vapor trap is announced by F. J. Stokes Machine Co., Philadelphia 20, Pa. Accurate readings, within the micron range, are obtainable even when condensable vapors are present in the vacuum system. The compact, built-in, renewable chemical cartridge protects the gage by absorbing all such vapors. Other features have been incorporated into the unit which can also be used to check quality of products being processed, to know whether or not a vacuum system is tight and functioning properly, to determine efficiencies of vacuum pumps and other equipment, etc. The unit is available in two models, zero to 5000 microns (5 mm) and zero to 500 microns.

Point-to-Point Communication Unit

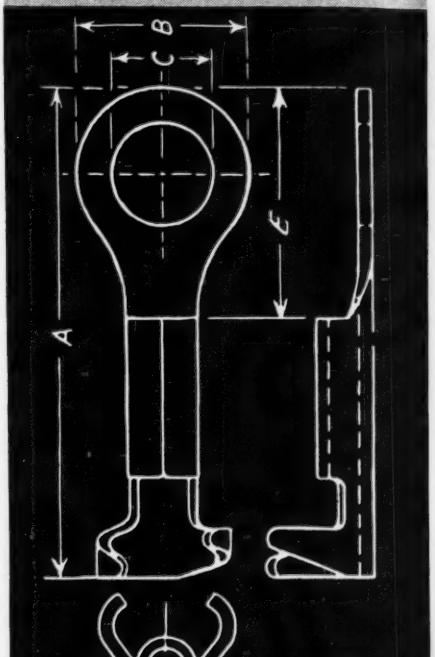
ILLUSTRATED ARE the Roto-Beam Rotator (top) and Synchro Anten-





a-Cator station control which will be available postwar to industry from Gordon Specialties Co., 823 S. Wabash Ave., Chicago 5, Ill. Message traffic (voice or code) is directed or beamed over a narrow arc which tends for secrecy, minimizes interference, and increases signal strength 6 to 9 db (power gain of 5 to 8) in the desired direction, without increasing the power of the transmitting source. The unit is effective on either transmission or reception.

Get the Specifications On This Improved One-Piece Solderless Terminal



You'll be amazed to see how production can be increased and performance improved, with the Sherman UNI-CRIMP One-Piece Solderless Terminal.

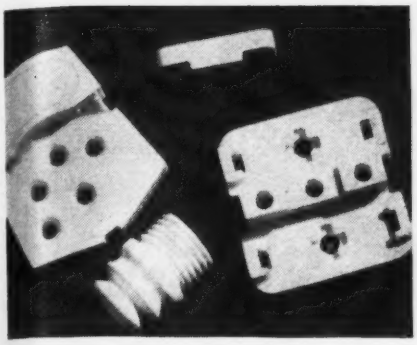
Here's a terminal that insures highest conductivity. It is made of fine grain, specially rolled, pure electrolytic copper, rated at 100% conductivity. And — the entire inside of the barrel is serrated, which provides a strong grip on the entire circumference of the wire, and *greatly increases the contact area.*

Write for Bulletin UC-2, giving full specifications. See for yourself why the UNI-CRIMP is stronger mechanically, more efficient electrically, easier to install, and more economical.

Find out how you can switch over to the UNI-CRIMP and speed up production, without any change in your present set-up.

H. B. Sherman Mfg. Co., Battle Creek, Mich.

The Sherman UNI-CRIMP Solderless Terminal



Lavite STEATITE CERAMIC

Properties and Characteristics of Our LAVITE SI-5 Steatite Ceramic Body

Compressive Strength	96,000	lbs. per square inch
Tensilie Strength	7,200	lbs. per square inch
Flexural Strength	10,500	lbs. per square inch
Modulus of Rupture	20,000	lbs. per square inch
Dielectric Strength	235	volts per mil
Dielectric Constant	6.42	Frequency of 1 megacycle
Loss Factor	2.90	Frequency of 1 megacycle
Power Factor	446	Frequency of 1 megacycle
Bulk Specific Gravity	2.664%	
Density (from above gravity)	0.096	lbs. per cubic inch
Hardness (Mohr scale)	7.0	
Softening temperature	2,350°F.	
Linear Coefficient of Expansion	8.13x10—6	
Moisture Absorption (ASTM D-116-42-A)	0.009%	

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY

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GENERAL CONTROL COMPANY

Put your foot down . .

TO PROVE THE SUPERIORITY OF THE NEW MODEL MK FOOT SWITCH

The NEW Model MK Foot Switch is safe, sure and fatigue-proof! It is designed for mounting on the floor, and the treadle is so close to the floor that the operator can rest his full weight in the most normal, most restful position. The hood over the treadle makes the Model MK absolutely safe—the foot must be inserted in the switch to actuate the control.

The Model MK employs the famous Acro switch unit which is your guarantee of millions of trouble-free operations. Write for details—the rugged construction and low cost will please you.

We are able to supply you from stock.

General Control Company makes a line of foot switches for every need—ask for Catalog No. 100.

MC MI MF MH

FOOT SWITCHES — HAND SWITCHES

1302 SOLDIERS FIELD ROAD BOSTON 34, MASSACHUSETTS

TEST INSULATION THE MODERN WAY

. . . WITH A MODEL B-5

MEGOHMER

NEW BATTERY-VIBRATOR TYPE

No more tiresome cranking of a hand-driven generator. Entirely self-contained. Steady test potential of 500 volts D.C. available at the touch of a switch. Direct reading in insulation resistance. Various new models and ranges.

Write or phone for Bulletin 430

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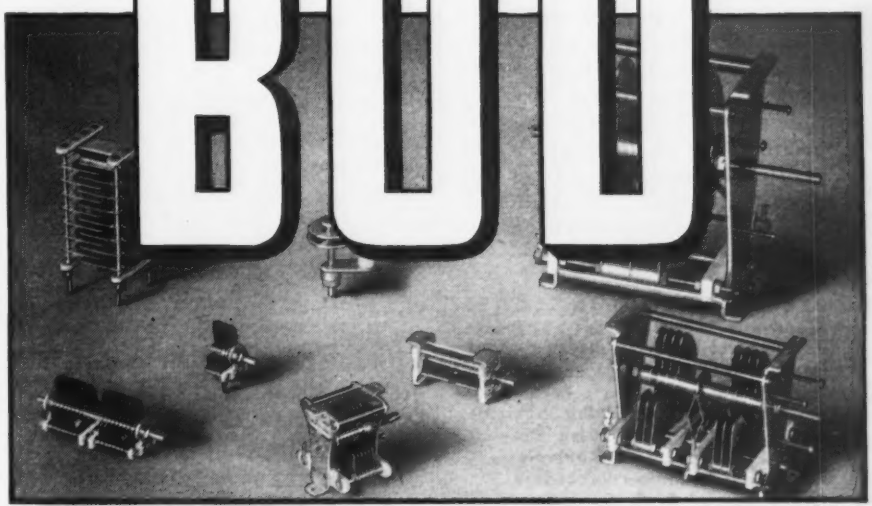
BUD



Answers your **CONDENSER** *needs quickly*

BUD condensers are made to meet most electronic applications . . . in sizes from less than an inch to over thirty inches . . . with a wide range of air-gaps, capacities and other mechanical details. Before ordering special condensers, consult the BUD Catalog. Chances are that you will find exactly what you want . . . at a saving in time and money! Write for your copy!

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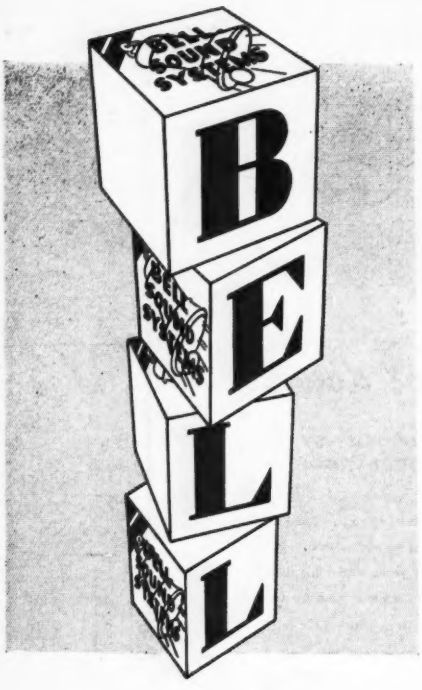

You may want to build BELL electronic controls or assemblies into your post-war plans

BELL may stack up perfectly — in both facilities and experience—as a source of electronic controls or assemblies to meet the needs of your post-war products or production. We'll gladly discuss the ABC's of electronics with you in terms of your specific problem. Why not write today?

BELL PRODUCTS INCLUDE: Electronic Sound Devices . . . Intercommunicating Systems . . . Industrial Voice-Paging and Broadcasting Equipment . . . Permanent and Portable Amplifying Systems . . . Recording and Disc Playing Units . . . Electronic Controls . . . Operating Sequence Recorders . . . Other Special Devices.

ARMY NAVY

BELL SOUND SYSTEMS

BELL SOUND SYSTEMS, INC.
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Export Office:
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Literature

Symbols for Electronic Diagrams. The Reference Sheet of graphical symbols for electronic diagrams which appeared in August issue is now available in reprint from at a cost of 10 cents each. The reprint is printed on heavier white coated paper and will be mailed flat so that it can be mounted and used as a handy and quick reference sheet. Write Electronics, Editorial Dept., 330 West 42nd St., New York 18, N. Y.

Standards Catalog. Available through American Standards Association (70 East 45th St., New York, N. Y.) is a new list of all American standards and war standards to date. Approximately 800 are listed under various fields covered by the Association and reference is facilitated by a separate alphabetical list. Typical of 1944 items in the electrical engineering category are:

C6.1. Terminal Markings for Electrical Apparatus.

C8.1. Definitions and General Standards for Wire and Cables (AIEE 30-1944).

C16.10. Volume Controls (Home Receiver Replacement Type) (American War Standard).

C29.1. Insulator Tests (AIEE 41-1944).

C39.2. Electrical Indicating Instruments (2½- and 3½-inch round, flush-mounting, panel type) (American War Standard) (2nd edition).

Standards Literature. Two pieces of literature, namely "Standards on Radio Wave Propagation" (definitions of terms relating to guided waves, 1945) and "Standards on Piezoelectric Crystals" (recommented terminology, 1945) are available at 20 cents each from The Institute of Radio Engineers, Inc., 330 West 42nd St., New York 18, N. Y.

Technical Reference Book. This book is a mechanically handy loose-leaf binder which embraces not only the manufacturer's products (United Electronics Company, manufacturers of industrial con-

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soon in production again

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TO THE MANUFACTURER OF

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★ STAR

DOUBLE-CHECK SYSTEM

#JE-10—Miniature socket wiring plug for accurate alignment of miniature socket contacts during wiring. Precision cast of zinc base alloy—Pins of stainless steel.

#JE-12 — (Hardened tool steel insert) or JE-13 (Stainless steel insert) Miniature tube pin straightener to obtain a perfect fit when the tube is placed in the set.

For complete information and prices—write

RADIO ACCESSORY DIVISION

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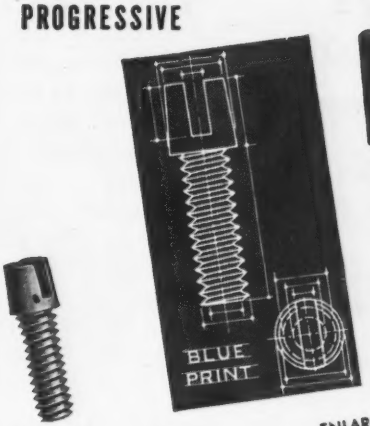
ANOTHER SPECIAL BY PROGRESSIVE

QUALITY PROMCO BRAND



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ENLARGED FOR DETAIL

CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, decimal equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.

The **PROGRESSIVE MFG. CO.**

50 Norwood St. **Torrington, Conn.**

★ BONDS BUY MORE WAR BONDS ★

SILVER

WIRE - SHEET - TUBING
SILVER BRAZING ALLOYS & FLUXES

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WIRE - RIBBON - FOIL
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WE INVITE INQUIRIES REGARDING ALL APPLICATIONS OF PRECIOUS METALS TO ELECTRONIC PRODUCTS.

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MICROTORQUE POTENTIOMETER

SENSITIVE • ACCURATE RELIABLE

FOR REMOTE RECORDING INDICATION CONTROL

FUNCTIONS

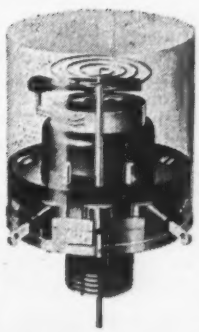
1 Can be directly coupled to low torque indicating meters or movements (existing pressure, temperature gauges, etc.) by simple yoke on instrument pointer without interfering with instrument indicating function.

2 Ideal for take-offs from bellows elements (pressure, temperature, flow, etc.) causing negligible drag on control element.

3 Ideal amplifier follow-up components in bridge-type control—relatively large electrical outputs for small mechanical inputs.

4 Operate directly recorder-controllers, recording galvanometers, milliammeters, oscillographs or polarized relays.

5 Indicate or record remotely positions of shafts, meters, or other mechanical elements.



FEATURES

1 Less than .003 oz. in. input torque.

2 Linearity ½% or better.

3 Weight less than ¾ oz. space envelope 1" x ⅞" cylinder

4 Vibration-proof, 4 to 55 cycles up to 6 g's.

5 2.5 Watts power dissipation.

6 Resistance 100 to 2500 ohms.

7 Jewel bearings, platinum metal brush and resistance material, highest quality contact performance.

8 Long life and dependability proved in many airborne and industrial applications.

9 Available in 270° potentiometer arrangement or continuously rotatable transmitter type—toroidal coil tapped at 120° intervals with twin brush take-offs separated by 180°

WRITE SECTION 5

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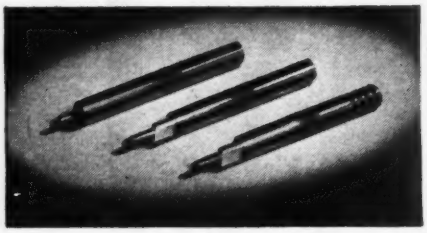
PASADENA 5, CALIF., U. S. A.

PRECISION PARTS

THREE STEPS TOWARD VICTORY



Fast communication between fighting-units gives the all-important coordination that often means the difference between success and failure. These tiny rotor-shafts are a vital part of an Army generator that develops the "juice" to send the messages back and forth.

Stainless steel bar-stock is centerless-ground to a tolerance of .0005". Next, the blanks are machined in automatic screw machines, the knurl being held to .002" on the outside diameter. The flats are straddle-milled and the shaft is completed by thread-grinding the worm.

This is typical of Ace work on small, accurate parts and assemblies involving stamping, machining, heat-treating, and grinding. You'll find Ace facilities and abilities offer many advantages. Send sample, sketch, or blueprint for quotations.

CURRENT CAPACITY AVAILABLE

CYLINDRICAL GRINDING—Multiple banks of widely varying internal and external cylindrical grinders are available for outside diameters up to 12" by 24" between centers . . . and inside diameters as small as 1/16" or as large as 4" by 2¼" long.

THREAD GRINDING—Our battery of Ex-Cell-O and J & L Thread Grinders equips us to give you tolerances of .0001" on all Standard V Threads, Acme and Square Threads, and on single or multiple leads. All sizes up to 5" diameter with threads 8" long, on parts up to 20" between centers.

ACE

TRADE MARK

ACE MANUFACTURING CORPORATION

for Precision Parts

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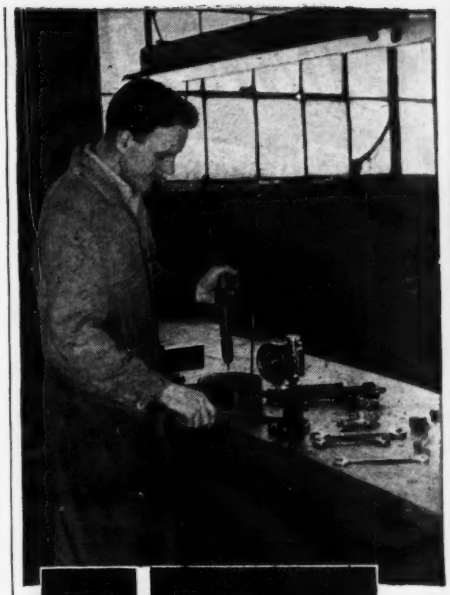
trol, radio transmitting and power tubes) but the general field of electronics. Among some of the chapters contained in the book are: "Basic theory of electron tubes; tube classifications and characteristics; tube manufacturing procedure; tube functions and modes of operation; circuit data; end uses of electron tubes; installation considerations; standardization practice; interchangeability chart; definitions of electrical terms; new standardized circuit symbols; conversion tables and a bibliography. Write United Electronics at 42 Spring St., Newark 2, N. J.

Speaker. A two-way multi-cellular loudspeaker (designated as The Duplex Speaker) for monitoring, radio, public address, recording, television and f-m reproduction, is illustrated and thoroughly described in a 12-page bulletin. The bulletin also contains a sound chart which shows the frequency coverage (from 40 to 15,000 cycles plus) of the speaker. Response curves for Model No. 605 Duplex loudspeaker are also given. Altec Lansing Corp., 1210 Taft Bldg., Hollywood 28, Calif.

Electrical Contacts. A new 36-page electrical contact catalog and data book designated as Contact Catalog No. 12 is published for manufacturers of products utilizing contacts. Many types of Stackpole contact materials and notes on the applications of each type is given. Stackpole Carbon Co., St. Marys, Pa.

Aircraft Communications Equipment. Type RTA-1B communications equipment for aircraft use combines ten crystal-controlled receiver and transmitter channels with integral power supplies into a single unit weighing less than 88 lb. The equipment is described in a 4-page bulletin from Bendix Radio, Baltimore 4, Md.

Magnavox Literature. Four separate pieces of literature from The Magnavox Company (Fort Wayne 4, Ind.) include: "A Reference Guide to Magnavox Electrolytic Capacitors" which is a 24-page booklet; and three single sheets which



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describe Model 14-12C, Model 12C and Model 305 (15-in.) dynamic speakers.

Ingot Iron. Advantages of ingot iron are given in a 24-page booklet entitled "ARMCO Magnetic Ingot Iron for D-C Applications." The iron is described as a dense, highly refined open-hearth iron with high conducting powers. The American Rolling Mill Co., Middletown, Ohio.

Headers and Sealed Leads. Data and specifications on E-I multiple headers and sealed leads are contained in a 6-page leaflet. Four basic types of hermetically-sealed headers are described in diagram form as well as in descriptive data. One page of the leaflet is devoted to hermetically-sealed terminals. Electrical Industries, Inc., 42 Summer Ave., Newark 5, N. J.

Nilsson Electrical Laboratories. Instrument manufacturing and service facilities of Nilsson are described in a 20-page booklet which also illustrates and describes some of the products (shunts and resistors, radio direction finders, audio amplifiers, vibration test table, etc) which Nilsson furnishes. 103 Lafayette St., New York 13, N. Y.

High-Vacuum Pumps. Improved Microvac pumps (with higher volumetric efficiencies and lower power requirements, and greater simplicity, than the models they replace) are described in a 4-page bulletin (No. 463) from F. J. Stokes Machine Co., Tabor Road, Philadelphia 20, Pa.

Vinson's Quarterly Report. The Director of War Mobilization and Reconversion has made his Quarterly Report (dated July 1, 1945) to the President, the Senate and the House of Representatives. It bears the title of "The Road to Tokyo and Beyond" and is available from the Division of Public Inquiries, Office of War Information, 1400 Pennsylvania Ave., N. W., Washington 26, D. C.

Bendix Radio Literature. Looseleaf sheets issued by Bendix Radio, Baltimore, Md., include Bulletin

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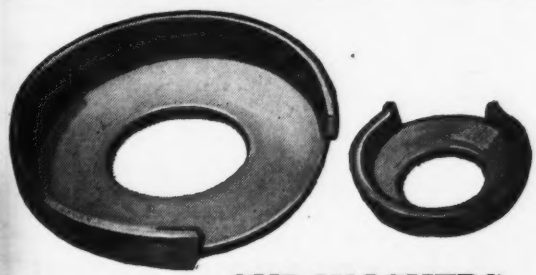

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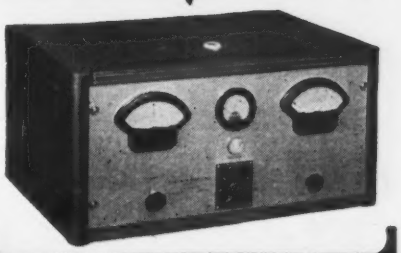

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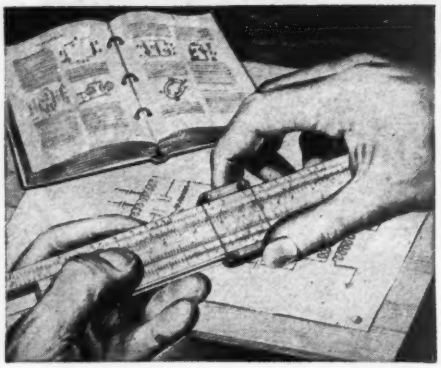

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No. SE-110 which describes Type MS-97 control desk for the master control position of a radio communication station handling a heavy volume of traffic; Bulletin No. SE-112 which describes Type MS-105A broad band dipole antenna, especially suited to aeronautical service operating in the range of 108 to 132 mc; and a 1-page leaflet on Type MT-48X antenna strain insulator.

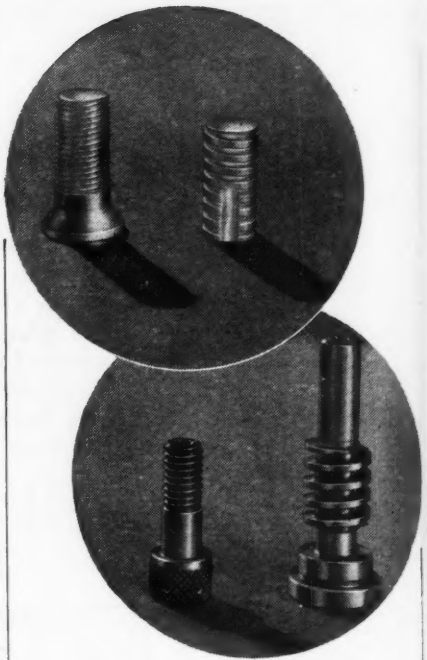
Dial Light Sockets. Catalog No. 101 contains 16 pages of illustrations and some descriptive data about dial light sockets for radio receivers and transmitters, test instruments and other electrical equipment. Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.

Microphone. Model BA-301 "Hushatone" is a miniature speaker designed for under-pillow use. A loose-leaf sheet from The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio, illustrates and describes the microphone.

Cathode-Ray Photography. A comparison of the essential characteristics of P-5 (calcium tungstate) and P-11 (sulphide) screens for cathode-ray photography are contained in a 1-page bulletin from Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J. Both screens are of the short persistence, blue fluorescent type and of high photographic actinity, the main difference being the considerably higher photographic and visual efficiency of the P-11 screen and the shorter persistence of the P-5 screen.

Rotary Power Equipment. Bulletin No. 445 is new and condensed and describes various generators, magmotors, converters and dynamotors manufactured by Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

Hermetically-Sealed Instruments. A 4-page bulletin illustrates and describes 1½, 2½ and 3½-in. hermetically sealed instruments for panel flush mounting. The Triplett Electrical Instrument Co., Bluffton, Ohio.



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NEW BOOKS

Cavity Resonators

By ALFRED DE QUERVAIN. Electrische Schwingtöpfe und ihre Anwendung in der Ultrakurzwellen-Verstärkertechnik (Electric "Pot" Resonators and their Application in Ultra Short Wave Amplifiers). *Published by A. G. Leemann & Co., Zurich, Switzerland, 1944, 86 pages, Fr. 6. —, RM 3.60.*

THIS SMALL German-language volume is an account of the author's work during the past few years on the theory and application of certain forms of cavity resonators to uhf amplifiers.

Although many variations are covered in the text, the fundamental form of resonator considered consists of an enclosed coaxial line cavity with capacitance loading at one end provided by a large disc on the central conductor, all dimensions being small in comparison with the resonant wavelength. Such cavities are designated by the author as "pot" resonators.

By treating these resonators as consisting of lumped inductance and capacitance, a graph is shown in which dissipative loss is plotted as a function of cavity dimensions for a series of reference cavities constructed of copper and for a given frequency and inductance. Since the values for unloaded Q and for parallel impedance are readily obtainable from the dissipative loss, cavities of any desired characteristics, within attainable limits, are easily proportioned by scaling the dimensions of a suitably chosen reference cavity from the graph. Although the resonators discussed throughout the book are for the range from 150 to 300 Mc, dimensions may be scaled down to the microwave range or up to the lower-frequency spectrum. An analysis of the temperature coefficient of frequency is given and a first-order method of temperature compensation is derived which consists of making the central conductor of two differing materials, having appropriately selected lengths and temperature coefficients.

Taking into account the well-known limitations of conventional tubes at these frequencies, the application of resonators as interstage coupling networks is thoroughly analyzed and a brief discussion of

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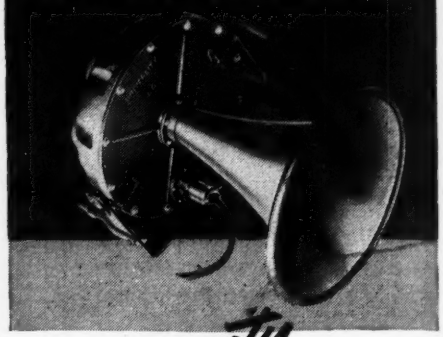

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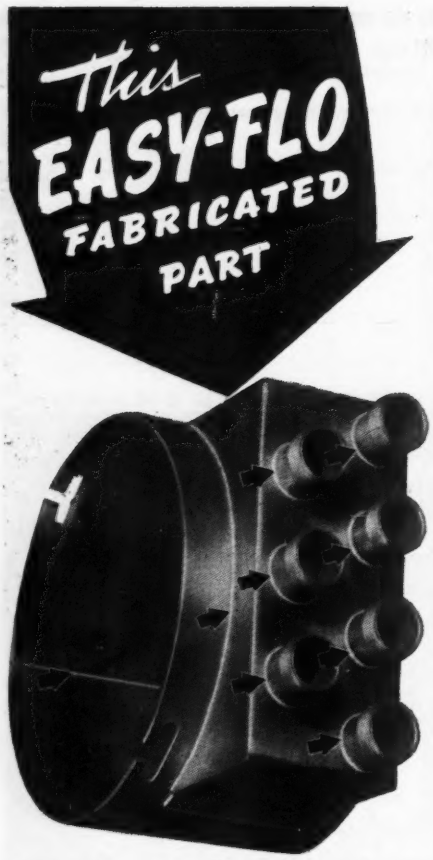

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coupling to generators and loads (receiving and transmitting antennas) is included.

Band-pass filters as interstage coupling networks, both theoretically and as applied to pot resonators, are treated in some detail. The capacitance-coupled band-pass filter is achieved by placing the resonators together with a common end-wall. The end-wall is pierced by an aperture permitting direct capacitance coupling between the two end-loading discs of the resonators. From measurements on an enlarged model, data is given in the form of a graph from which the coupling capacitance can be directly determined. Inductive coupling between the band-pass elements is obtained by employing as the common end-wall the short-circuiting sections of the resonators and providing the end-wall with apertures. Experimental data is given as an aid in determining the inductive coupling. This form of coupled resonator construction lends itself to a clean-cut mechanical layout since the tubes can be mounted between resonator pairs.

An adjustable magnetically coupled resonator pair is described in which a rotating element permits adjustment of the coupling apertures. Variations of resonators employed as four-terminal matching networks are briefly discussed.

The remainder of the book is devoted to a discussion of measurement apparatus and data together with a discussion of results. Data are given on Q measurement, capacitance and inductively coupled filters and including some information on the measurement of metallized resistors. It seems quite likely that the application of such resonators to the precision measurement of resistance and of the dielectric properties of materials in the uhf region will assume considerable importance.

Finally, a two-stage pentode amplifier utilizing a band-pass filter consisting of three inductively coupled resonator sections is discussed in detail. Mechanical design is shown and performance characteristics are given which satisfactorily confirm the theoretical treatment presented in the text. A bibliography of both American and continental sources covers the field.

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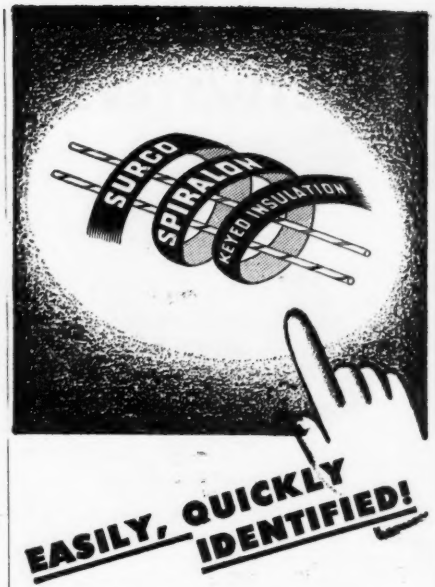

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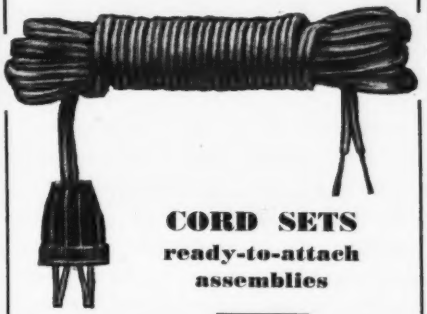

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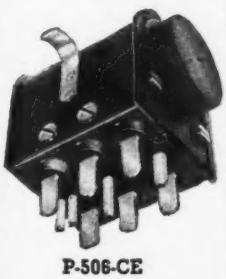

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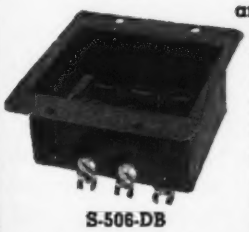

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lumped-parameter circuit theory point of view, the material in the book is clearly presented and it should prove of interest to engineers designing equipment and to those engaged in measurements in this general frequency range.—H.H.

• • •

Television Programming and Production

By RICHARD HUBBELL. *Published by Murray Hill Publications, Inc., New York, 1945, 207 pages, $3.00.*

TELEVISION HAS long needed an evaluated summary of its programming experiments. Within limits this book fills that need. Unfortunately, the title promises more than the text gives. It deals with production methods (excepting remote pickups), but fails to discuss types of programs, a study important because successful televising of some subjects will require equipment (and studios) not yet designed.

By way of introduction to a theory of video technique, television is compared with allied arts. The notes on video broadcasting vs. the theater or the motion picture are a scrambled rehash of social, economic, and artistic aspects of drama and film, contributing no new conclusions toward the development of a television art. When discussing radio and television, the author is more at home. Part Five: "The Audio" is likewise provocative.

The kernel of the production recommended is an appeal for greater camera mobility patterned after current motion picture equipment. "Since television can not equal the tempo of film cutting but can exceed the mobility of the motion-picture camera, it seems that a promising field of development is to be found in this characteristic."

The reviewer can not agree with this basic assumption. Television can match the rhythm patterns of film technique providing improvements are made in camera design—smaller size, less weight, greater sensitivity—so that greater numbers can be employed. Greater camera mobility seems to be an undesirable path for television to follow because it would increase the complexity of production,

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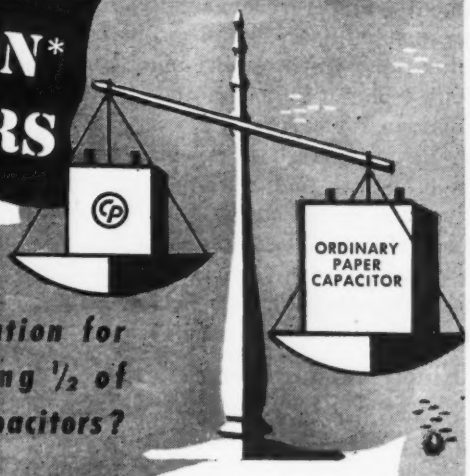

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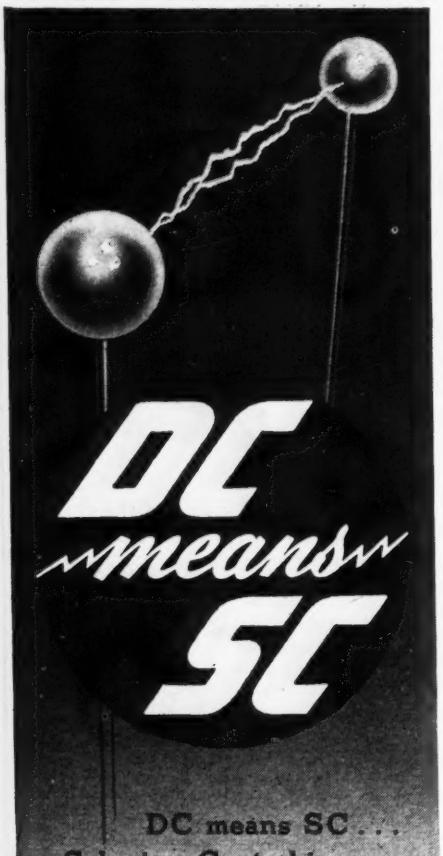

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• • •

Electrical Drafting

D. WALTER VAN GIESON. *McGraw-Hill Book Co., New York 18, N. Y., 140 pages, $1.50.*

KNOWLEDGE OF WIRING PLANS and the methods of their development is a valuable asset to the engineer or draftsman entering the electrical profession. Yet the technique of this special field of drafting has received slight attention in the conventional teaching of drafting. To fill this void and to acquaint the student with the procedure followed in the preparation of wiring and circuit drawings, the author has assembled typical examples of electrical installation drawings which are used in many fields.

This is not a book dealing with the use of drafting instruments; the author assumes that the student has had previous training in that manual art. This pioneering volume explores and discusses, through the analysis of practical problems, the special drafting technique used in the preparation of electric circuit diagrams and wiring plans. At first glance, because of the short chapters, it might appear that the treatment is too brief. But, considered from the standpoint of an overall coverage of fundamentals and practical procedure, the text is adequate as a basis for an excellent course in the subject.

Much theory is included in the presentation of the several divisions of the electrical equipment and installation field. Following a discussion of symbols, schematic sketches and finished circuit drawings, the author interprets wiring diagrams as used for many purposes.

Circuit and wiring plans are illustrated and analyzed for lighting, railway signals, communication, radio, television, power installations, switchboards, automobiles,

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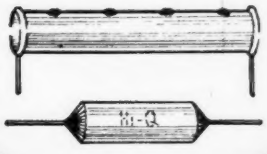

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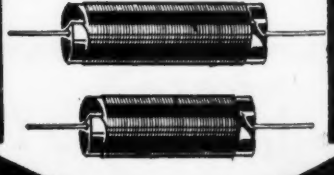

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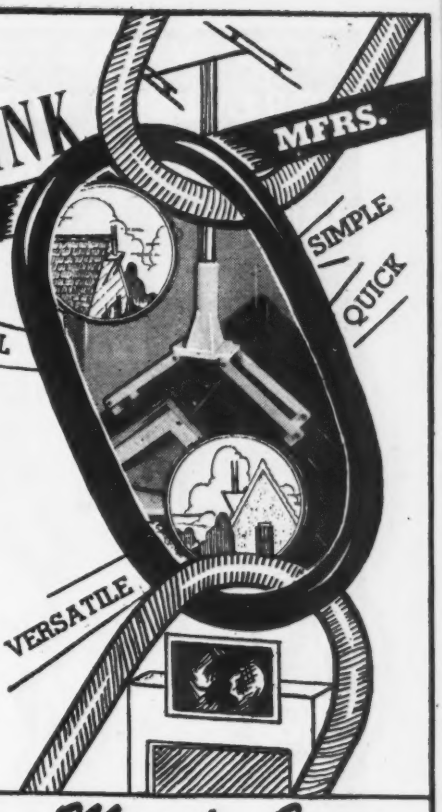

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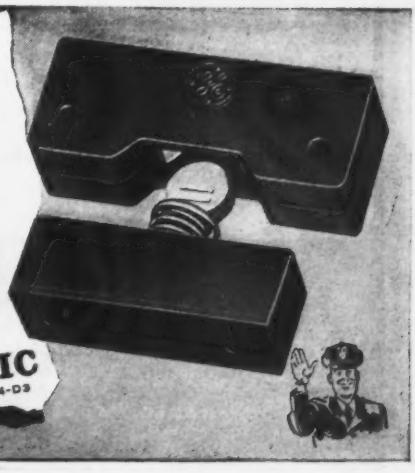

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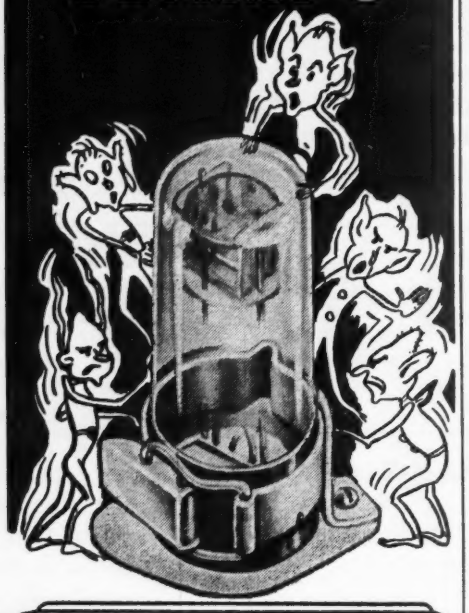

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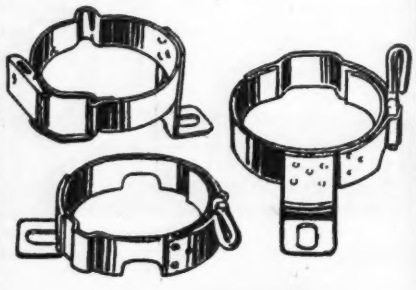

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Automatic Telephone Practice

HARRY E. HERSHEY. *Technical Publications, Whitewater, Kansas. Advance printing of Part C—Circuit Kinks—from Fifth Edition, 1945, 24 pages, $1.00.*

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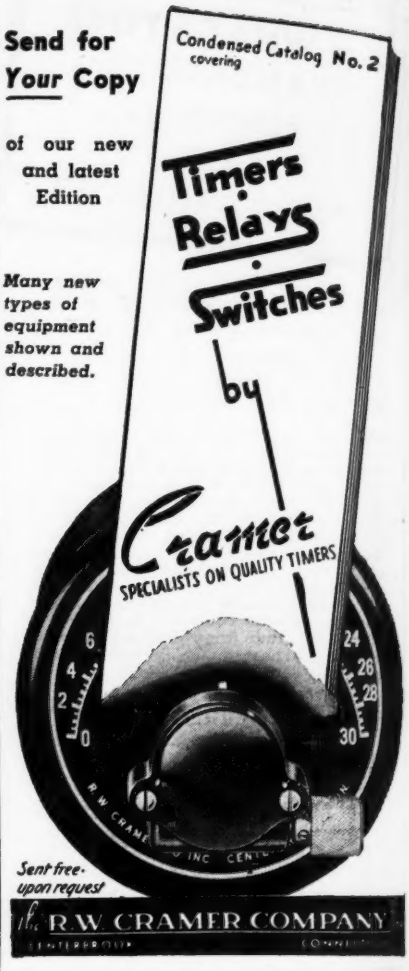

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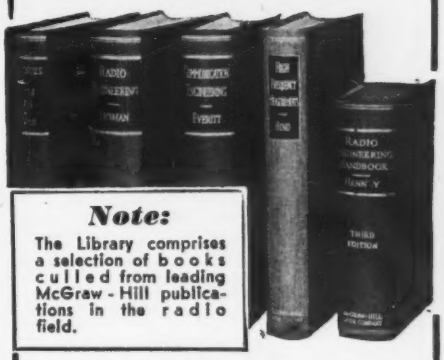

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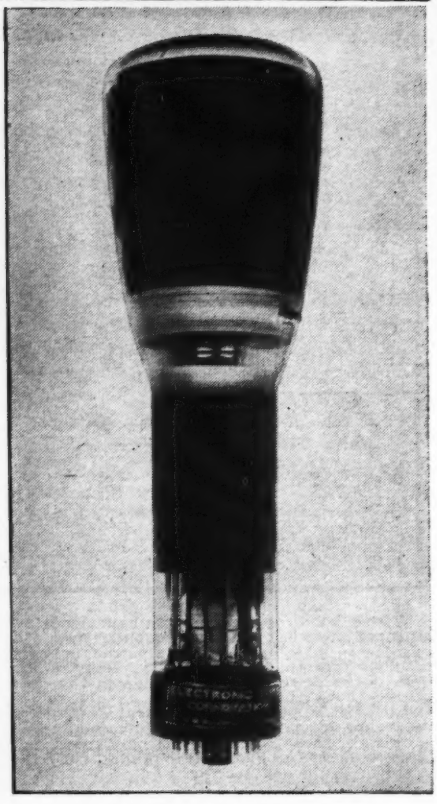

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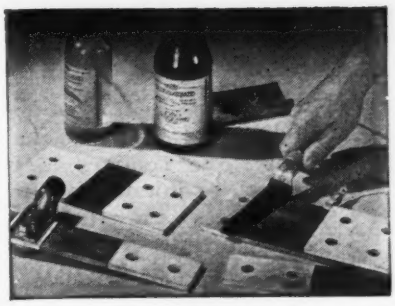

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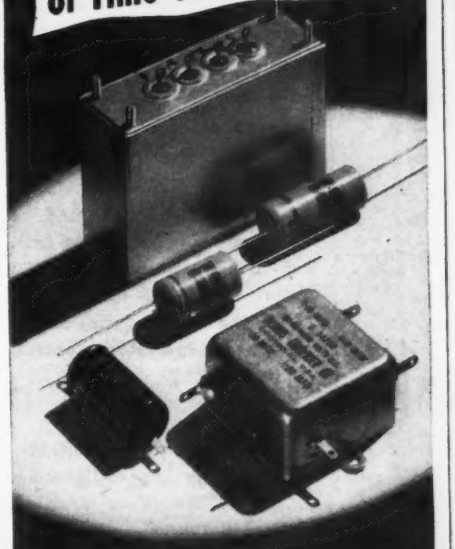

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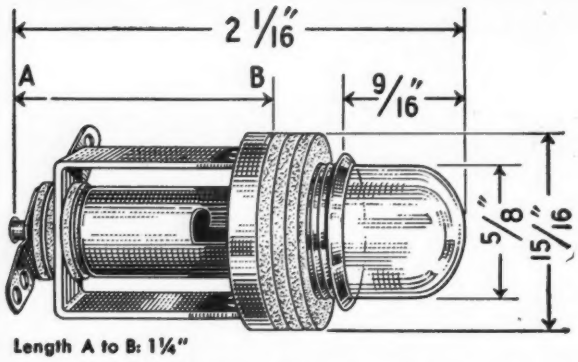

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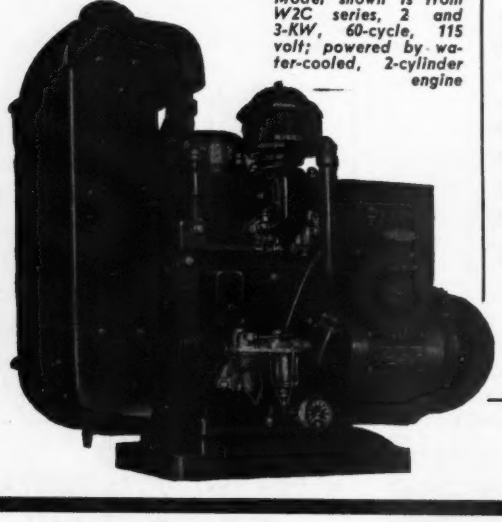

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Signal Level

Gentlemen:

Mr. Charles E. Gardiner, in the Backtalk department of the June issue of ELECTRONICS, suggests the symbols $\frac{1\text{ v}}{100\text{ db}}$ and $\frac{30\text{ db}}{1\text{ w}}$ to represent 100 db below 1 volt and 30 db above 1 watt. Without any explanation of symbolism, the usual practice is that the numerator be read first, which would make the former appear to be 1 volt above 100 db. I would suggest, instead, 100 db\1 v and 30 db/1 w— in other words, \ for "below" and / for "above." No hardship on Mergenthaler, either.

B. HARA
New York, N. Y.

• • •

Pickup Terminology

Gentlemen:

THE OBJECT of this letter is to call your attention to an error in your June 1945 issue, page 108, Moving-Coil Pickup Design.

Whether a moving conductor cuts the flux lines, or the flux lines cut a stationary conductor is of no consequence, so long as the final results are what is desired. It is specifically the writer's wish not to go into any discussion of the merits or demerits of the general structure of the device in question. However, as described, the device is actually a "moving inductor" type, and the voltage generated in the coil is due to variation in reluctance between the magnet poles and the vibrating steel tube—or armature.

As a matter of fact, the vibrating mass would be much lower and the results better, if the coil were stationary and not carried by the moving steel tube. To the writer, it appears that originally, the coil was wound on an aluminum tube, in which case the reluctance in the gap was fixed and in that case, the vibrating coil would cut the flux. However, because the resultant out-

(*Continued on page* 424)

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(Continued from page 416)

put was much too low, the steel tube was then added. This, of course, increased the output as a result of variation of the reluctance in the gap.

N. PAYNE
New York, N. Y.

Dear Mr. Payne:

I can easily understand how you might get the impression of a moving inductor after reading the article. The coil wound on the sleeve rocks through a very small angle on its own center so that any magneto-inductive action of the sleeve essentially cancels out.

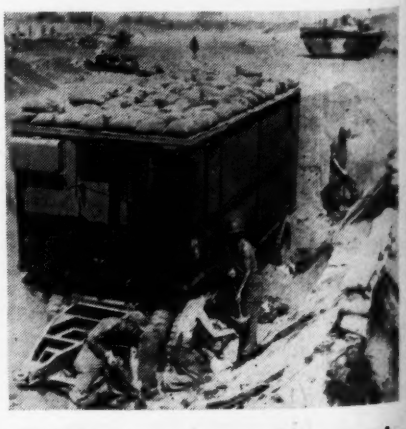
In other words, if it were possible to support the coil in its present position and rock the stylus and sleeve only, little output would result, as the top half of the sleeve would approach slightly say, the North pole, and its effect of changing the reluctance of the gap would be nearly cancelled by the corresponding opposite motion of the bottom half of the sleeve.

The only real reason for using the sleeve is to raise the flux in the gap and concentrate the flux lines through the sides of the coil. Further, if this device relied upon an armature of the type Mr. Payne has in mind, its performance would depend upon the linearity of the metal used. In this case the sleeve is actually saturated at all times and the output remains as that of a moving coil except for the considerable increase in efficiency as a result of the intensified and controlled gap.

T. W. LINDENBERG
Fairchild Camera & Instrument Corp.
Jamaica, N. Y.

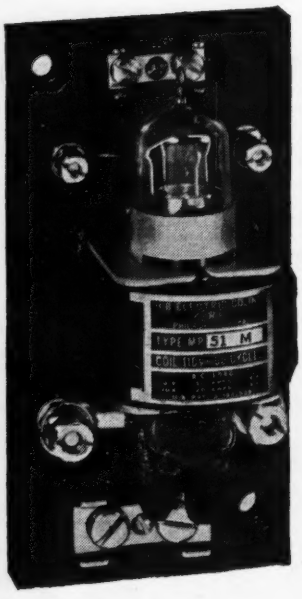
• • •

Radar on Iwo Jima



U. S. Army men place sandbags around a truck containing plane-detection equipment used in conjunction with antiaircraft guns on Iwo Jima

put this RELAY to work with electronic tubes



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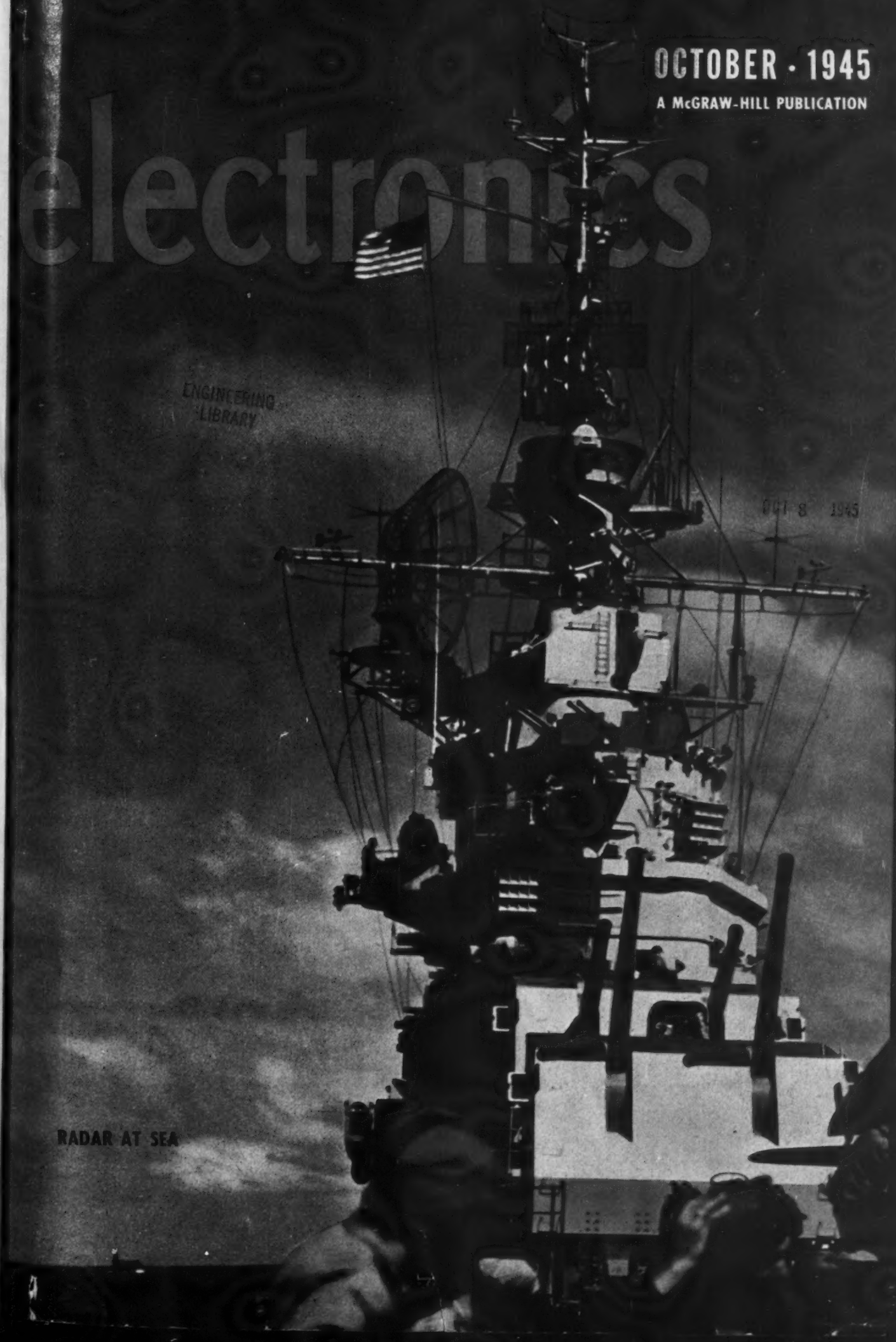

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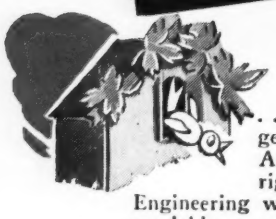

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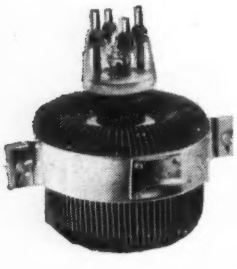

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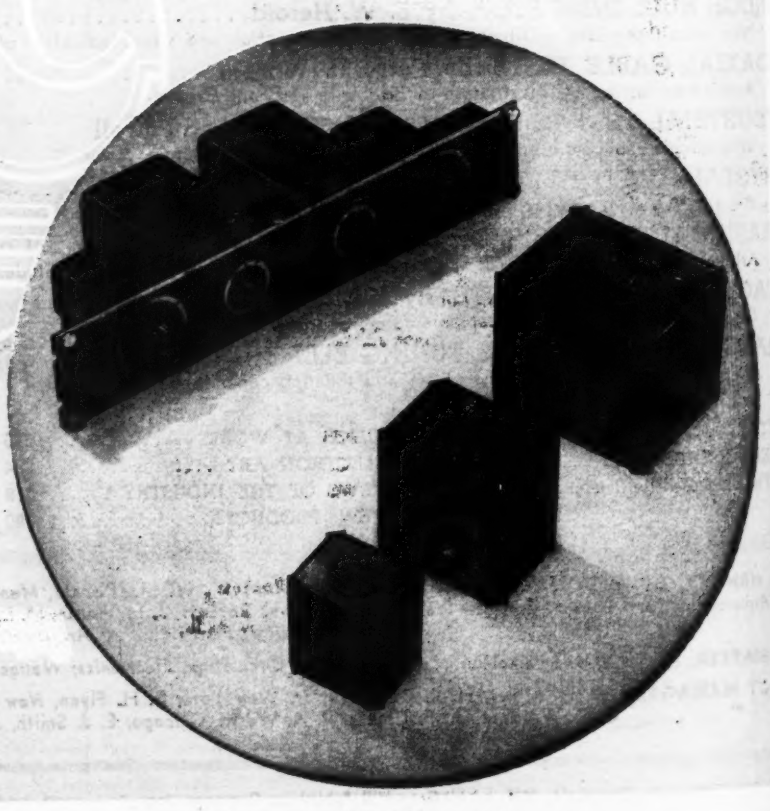

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